Memory Development of Libyan and Dutch Children

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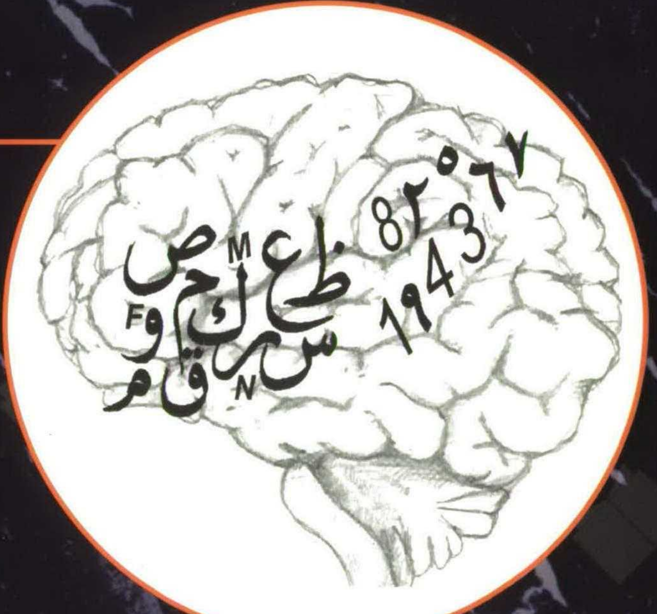

Mostafa Shebani

Memory Development of Libyan and Dutch Children

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PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Katholieke Universiteit Brabant,
op gezag van de rector magnificus, prof.dr. F.A. van der Duyn Schouten,
in het openbaar te verdedigen ten overstaan van een
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Tilburg University

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Prof.dr. Y.H. Poortinga

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To: my wife, Naima,
and my children, Suheil, Huda, Isra, Mohamed, Anas, and Bushra,
the best of this research is dedicated.

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Preface

The psychology of memory has been an enormously active field of research the last thirty years. Interest in memorial behavior among cognitive psychologists and psychometricians is usually driven by its close relationship to intelligence. In this report a review of the literature is presented followed by an account of three empirical studies.

Based on a conception of memory components that has been guided by the development of information-processing theory of cognition, convergence of opinion has been reached on major aspects of memory. The accumulated evidence has been strongly in favor of a distinction between short-term and long-term memory storage. The storage capacity of the system is an integral part of its capacity to perceive, attend, and reason. Claims about the short-term store postulate that this store acts as a working memory, a system for temporarily holding and manipulating information on a wide range of essential cognitive tasks, such as learning, reasoning, and comprehending.

Early research in memory has been inspired by interest in sources of individual differences in memory capacity. Research on memory development has investigated memory abilities as a function of age and individual characteristics. Various models were formulated and have been used as a framework in much laboratory research. Baddeley and Hitch (1974) have proposed a model of working memory. The basic prediction in this model is that reading speed determines the amount of information that can be refreshed and recalled per unit of time. This prediction has been under extensive investigation in a number of laboratory studies designed to examine memory capacity with children (e.g., Hulme, Thomson, Muir, & Lawrence, 1984; Kail, 1992) as well as with adults (Baddeley, Thomson, & Buchanan, 1975). However, evidence in support of the hypotheses derived from the model has not been conclusive.

Research in memory has sought to identify factors other than age and maturational changes that may account for the development of memory skills. Among these are mnemonic strategies and self directed skills, i.e., mental 'tricks' or acquired methods that make the stimulus array seem more orderly, or that help keep information in mind. Several lines of research suggest that training with task-specific methods is likely to be successful in improving memory performance. Practicing acquisition in a particular kind of memory task (e.g., the digit span task) has been found to induce superior memory abilities for that task (e.g., Chase & Ericson, 1982).

Memory investigators are interested in an individual's knowledge about his or her own memory ability. A new line of research has been initiated by Flavell (1971), and Flavell and Wellman (1977). Flavell introduced the term 'metamemory' to refer to the knowledge that individuals have about memory process. Metamemorial knowledge centers around three areas: knowledge about own abilities in memory functioning, knowledge about a task and how it might affect memory performance, and strategy knowledge, i.e., knowledge about the use of memory enhancing strategies. The linkages between knowledge about memory and the learner's efficient use of strategies are a main target of exploration in metamemorial research.

Constructs of memory capacity, strategies, and metamemory were also introduced and investigated in cross-cultural studies of memory and memory development. The basis of such research was the view that these constructs become more clear and better understood when explored across cultures. The cross-cultural approach in psychology is an important research strategy for two reasons: first, it allows the investigator to extend psychological statements, based on data collected from restricted subject population to other populations; and second, it allows the investigator to study previously confounded or non-separable variables such as years of age and level of schooling whose ranges are constrained in Western society. Cross-cultural research in memory seems to have begun with the idea of studying the generality of psychological functions and processes. Investigators such as Lévy-Bruhl (1910) and Bartlett (1932; see Segall, Dasen, Berry, & Poortinga, 1990) made widely different statements about memory among 'primitives,' with claims varying from poor to excellent. In more recent research, the cross-cultural strategy has been used primarily to study the effects of different environmental factors on cognitive abilities. Implicit in such studies is the need to establish antecedent experiences that are likely to produce measurable differences in behavior, or, if such differences do not occur, to support the notion of psychological universality. One variable that has attracted considerable interest is that of schooling experience. For example, Wagner (1974) showed that by age 14, urban in-school children of Yucatan were performing better than rural out-of-school children on serial short-term memory tasks. Large differences emerged in processes of verbal rehearsal.

Three empirical studies are discussed that were carried out to compare Libyan and Dutch children's performance on a number of memory tasks. The first study reports a cross-cultural test of a hypothesis formulated by Baddeley regarding the effects of word length on memory span. A unique feature of numerals in Arabic (i.e., the existence of long and short words for the same digit) was used. The second study examines rehearsal-training effects on short-term memory span of Libyan and Dutch children. The third study was designed to explore the relationship of metamemory and memory. A metamemory test battery was constructed and administered to groups of Libyan and Dutch children. The internal consistency of the battery was evaluated by examining intercorrelations of subtests. The validity of the metamemory battery was tested by correlating the subtest scores with grades on scholastic achievement tests.

This report consists of eight chapters. The first four chapters review empirical research on memory capacities, memory strategies, metamemory development and cross-cultural research in memory development. Chapters five, six and seven contain the empirical studies comparing Dutch and Libyan children on three aspects of memory: memory span, rehearsal training and metamemory development. Finally, the main findings of the empirical studies are summarized in chapter eight.

M.F.A. Shebani

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Part I

Literature Review

Chapter 1

Memory Mechanisms and Their Development

1.1 Introduction

The question of how memory operates is not easy to answer. Several views have been proposed to explicate the mechanisms of memory. The 'unitary memory' view is that the same rules of learning apply to all memory tasks, from those lasting a few seconds to those lasting hours or days (Crowder, 1993). The 'dual-storage' view states that the human mind includes separate short- and long-term storage mechanisms (Atkinson & Shiffrin, 1968; Waugh & Norman, 1965). The distinction between short-term memory and long-term memory has become a central feature of all major information processing theories of memory. The main property of short-term storage is that it is based on a temporary memory representation that deteriorates or decays within a minute or less. Long-term storage would be subject to forgetting from contextual changes and interference, but not to decay. The unitary memory view holds that memory in any task is not susceptible to decay, but only to retrieval failure owing to particular factors such as interference and shifts in context. This view contradicts the current models of memory, which are in favor of a short-term memory store with limited capacity.

Evidence that can be viewed as supporting the existence of short-term store have come from 'free recall' procedures, in which a list of words is presented in either written or spoken form. The list is then repeated with the words in any order that the subject finds convenient. This type of procedure results in a U shaped recall function, with much better recall of the words presented near the beginning and end of the list and poorer recall of words presented in the middle. The superior recall at the beginning of the list, or 'primacy effect,' is thought to occur because the first few words can be attended and rehearsed without competition from other items. In contrast, the superior recall at the end of the list, or 'recency effect,' is thought to occur because the short-term memory representation of the last few words has not yet decayed much by the time of recall. In support of this interpretation, Glanzer and Cunitz (1966) found that a distracting task interposed between the end of the list and the subject's recall left the primacy effect unaltered, but greatly reduced the magnitude of the recency effect.

Evidence for memory decay fits in with Baddeley's (1986) notion of a verbal 'articulatory loop,' a system in which a phonological store of limited capacity coupled with a control process of subvocal rehearsal presumably retains verbal information. Memory traces in the store decay rapidly unless refreshed by covert rehearsal. This suggests that the persistence of information in the store without rehearsal is only about two seconds before it is totally lost from storage through decay. Other evidence for the existence of a short-term store and for the notion of memory decay came from cases of neurological damage. Severe bilateral damage to the hippocampus, an area embedded within each temporal lobe of the brain, prevents the patient from learning anything new in a way that can be deliberately, consciously recalled later (Squire, Knowlton, & Musen, 1993, quoted in Cowan, 1997).

In general, it seems attractive to some investigators to have a unitary theory of memory with few explanatory principles and no concepts of memory decay. However, there are important aspects of the evidence that the unitary memory theorists have yet to explain. These aspects seem more readily explainable using the concept of memory decay.

1.2 Models of Memory

When Ebbinghaus (1885, quoted in Greene, 1992) introduced the experimental approach to study human memory, he was aware that the most important factors influencing recall and retention are subjects' knowledge and interest. In fact, his approach was to eliminate, or at least to minimize, the effects of relevant experiences through the study of memory for unfamiliar materials, such as nonsense syllables. Furthermore, he relied on rapid sequential presentation of material to exclude use of acquired skills and strategies. This approach allowed Ebbinghaus to study the basic mechanisms for strengthening associations and to discover general laws of memory. Since then researchers have continued to derive general laws and capacities for memory from simple tasks with arbitrary sequences of information explicitly designed for the study of memory performance. The standard procedure has been to present a list of unrelated items and to require reproduction with either immediate free recall or free recall after some interpolated activity.

1.2.1 Two-Store Model

The model of human memory that Atkinson and Shiffrin (1968) have introduced is a two-store model. It proposed a distinction between a temporary short-term store (STS) and a more permanent long-term store (LTS). A basic assumption of the model was that storage of information in LTS is determined by the processing of information in STS. It has been emphasized that STS should not be viewed as a physiologically separate structure. Rather, it should be thought of as a temporarily activated portion of LTS. This STS is serving the dual purpose of maintaining information in a readily accessible state and of transferring information to LTS. What gets stored in LTS is determined by the type of processing (attention, rehearsal, and coding) that is carried out in STS. Rehearsal or coding processes are under the control of the subject and are used to maximize performance by devoting all mental effort to rehearsal and not engaging in other mental activities.

Atkinson and Shiffrin (1968) distinguished between two STS control processes, namely rehearsal, to maintain the information in STS, and coding, to store information in LTS. These two aspects, should in practice be regarded as the end points of a continuum; where rehearsal processes lead to the storage of information in LTS, and coding processes will similarly keep information in an active state, and hence in STS. In the original version of the model the authors focused on rehearsal assuming that storage in LTS is a function of the length of rehearsal period. In later analyses (Shiffrin 1975), this assumption was clarified by replacing the terms 'rehearsal' and 'coding' with 'maintenance rehearsal' and 'elaborative rehearsal,' respectively. According to the two-store model, elaborative rehearsal has the primary function of storing information in LTS.

Hence, it is not the amount of rehearsal per se that determines recall, but rather the amount of elaborative rehearsal that can be practiced in a free recall situation.

There have been several new theoretical developments since the model was originally proposed by Atkinson and Shiffrin (1968). Examples are the cross-cultural validation that has been conducted by Wagner (1976), and a contemporary version of the model that has been developed by Raaijmakers and Shiffrin (1980, 1981) under the name of search of associative memory (SAM). The basic framework of the SAM model assumes that during storage, information is represented in 'memory images' which contain item, associative, and contextual information. The amount and type of information stored is determined by coding processes in STS (elaborative rehearsal). The amount of information stored is a function of the length of time that the item is studied while in STS. Retrieval from LTS is based on cues, that can be words from the studied list, category cues, contextual cues or any other information the subject uses in attempting to retrieve information from LTS. Successful retrieval depends on associative strengths of the retrieval cues to that image. These strengths are a function of the overlap of the cue information and the information stored in the image. The strengths are a linear function of the amount of elaboration rehearsal (the amount of time the item is actively rehearsed). The SAM model was proposed to integrate phenomena from various memory paradigms within a single theoretical framework. Quantitative accounts have been developed for free recall, paired-associate recall, interference and various recognition paradigms (see Raaijmakers, 1993).

1.2.2 Levels-of-Processing Framework

Following the introduction of the two-store model, Craik and Lockhart (1972) proposed an alternative framework for human memory research. They argued that the strength and persistence of a memory trace is determined by the depth to which the to-be-remembered material was processed. This theory distinguishes between two types of processing. One type refers to continued processing at a level that serves to maintain the information in what was termed 'primary memory.' The other type involves the processing of information at a deeper level that should lead to better memory performance. In fact, the distinction between the two types of processing is virtually the same as the distinction mentioned earlier between maintenance and elaborative rehearsal. In support of Craik and Lockhart's claim, several experiments were conducted. Craik and Tulving (1975) showed that the ease with which words were recognized or recalled was very much dependent on the task that the subjects had been given to carry out. The most important determinant of the level of subsequent recall was the requirement that the subject should consider the meaning of the list words (i.e., a semantic task). In general, semantic tasks led to considerably greater recall than did non-semantic tasks, presumably due to the greater depth of processing of the former. The depth-of-processing approach has been successfully applied to sentence memory, where the evidence indicates that the more deeply sentences are processed the higher the level of recall (Treisman & Tuxworth, 1974).

Craik and Tulving (1975) have proposed some extensions of this approach, arguing that both the depth of encoding and the spread or elaboration of encoding in various encoding domains are important determinants of memory performance. The more attributes of a word are encoded at input, particularly those at the deep level, the more elaborate will be the resultant memory trace. Further evidence that the spread of processing is an important determinant of retention has been obtained in studies using imagery instructions. Morris and Stevens (1974) presented their subjects with a list of words, and required them either to form interactive images of groups of words, or to produce separate images of each word. In spite of the fact that the same depth of imaginary processing was presumably utilized under both instructional sets, interactive imagery produced much greater recall.

While the levels of processing theory was an important step forward with its emphasis on the tasks and type of processing that are undertaken, the model shows a variety of problems. Neither depth nor spread can be satisfactorily indexed; some of the experimental evidence was inconsistent with the model; retrieval processes were underemphasized; and a proposed classification of word attributes into physical, phonemic and semantic was ad hoc. According to Raaijmakers (1993), it is problematic that the levels-of-processing model has never been described in a quantitative form. The criticisms were mainly directed at the problem of measuring independently the depth or level of processing that has been achieved, and the overemphasis on the specific nature of the encoding process without recognizing the importance of conditions during retrieval.

1.2.3 Working-Memory Model

The distinction between short-term memory and working memory is that the former involves only storage and reproduction of information, while the latter includes the capacity to transform information being held in the short-term system. With the working memory construct the focus is on the active processing capacity. The construct has been used to explain performance on a variety of cognitive tasks. It can be conceptualized as a cognitive process in which certain bits of information are held in a memory store characterized by limited capacity for storing and by rapid decay, while other bits are retrieved from long-term storage. However, the existence of a single mechanism serving these functions is implausible. Rather, it has been suggested that several mechanisms codetermine the capacity and properties of working memory.

The major theories in this field posit different mechanisms or components of working memory, and different developmental process. For instance, Baddeley and Hitch (1974) developed a model, according to which short-term memory is not a unitary phenomenon. They suggested a triple system, composed of a Central Executive, which is a control mechanism helped by two slave systems: the Articulatory Loop (AL) and the Visio-Spatial Sketchpad (VSSP). The two slave systems are assumed to function independently from each other, as demonstrated by the use of dual task paradigms (see below).

The Central Executive (CE) is an attentional system, with a limited capacity. It has been relatively little studied, and according to Van der Linden (1989, quoted in de Ribaupierre & Bailleux, 1994) remains some kind of a 'conceptual black box.' Recently, experimental studies have directly addressed the CE. For instance, Baddeley (1992) considers that the great difficulty Alzheimer patients have to coordinate information from different sources, with one calling for the AL system and the other one for the VSSP system, is due to a deficit of the CE. Thus, the CE is mainly viewed as a mechanism for monitoring and coordinating the processing of information.

The Visio-Spatial Sketchpad is responsible for holding and manipulating visual and/or spatial information. Experimental studies that explore the system are limited, and results are sometimes difficult to interpret. In particular, the rehearsal mechanism and the limits of the system remain largely unknown. The work of Baddeley (1988; Logie & Baddeley, 1990; Logie & Marchetti, 1991) tends to show that it consists of two distinct components, a visual and a spatial one.

The Articulatory Loop is the most frequently studied part of the triple system; its role is to hold and manipulate verbal material. It consists of two components: a phonological store, which is relatively passive and to which verbal material presented auditorily has obligatory access; and a rehearsal mechanism which helps to maintain stored items as well as recoding verbal material presented visually. The AL is limited temporally: it contains as many items as can be rehearsed in approximately 1.5 to 2 seconds. Therefore, it is closely linked to articulation rate. The functioning of this subsystem accounts for phenomena repeatedly observed in verbal short-term memory studies, such as the effect of word length, articulatory suppression, and phonological similarity.

1.2.4 Neo-Piagetian Theory

The Neo-Piagetian models are not all alike, nor do they all explicitly address working memory (e.g., Case, 1987, 1992; Dasen & Ribaupierre, 1987). Furthermore, different constructs have been used, such as attentional capacity, mental space or M-space, mental power or M-power, mental attention, and processing space. One should note that these constructs are broadly equivalent, in the sense that they all refer to a limited capacity for storage and manipulation of mental information. Thus, the role assigned to working memory is the same in these models as in Baddeley's approach. As noted by Case (1995), the concept of M-space, would be referred to as working memory today.

The first influential neo-Piagetian model of working memory was proposed by Pascual-Leone (1970, 1987). The model is in accord with current views of working memory, emphasizing processes that activate information. The theory is an interpretation of Piaget's structural model of intellectual development, using the Piagetian concept of schemes. The theory includes two levels of cognitive operators. At the first level there are cognitive units, called schemes (a scheme has a specific information content, and a subject's long-term memory is called his/her repertoire of schemes). This level is divided into three components. There are figurative schemes, operative schemes (see

Anderson, 1983, for a similar distinction between declarative and procedural knowledge, or pragmatic knowledge that include information and strategies), and executive schemes, that stipulate goals, plans and well-practiced procedures. The activation of particular figurative or operative schemes is orchestrated by executive schemes.

At the second level there are general-purpose mechanisms or 'silent operators' that have the function of increasing or decreasing the activation of schemes. The mental operator or M-operator is conceived as a mechanism, controlled by the executive schemes and endowed with limited attentional resources, having the function of activating a limited number of task-relevant schemes. The inhibition operator, or I-operator, is a mechanism complementary to the M-operator in that it inhibits task-irrelevant schemes. The learning operator, or L-operator, represents the learning of new schemes.

According to Pascual-Leone's theory, no task is performed by means of a single operator. The various operators are assumed to concur in the performance of a given task. When new information is processed, a rather large set of schemes is activated, most of them automatically. These schemes represent the 'activation field.' Depending on the situation, certain schemes in this field are inhibited, whereas others are more strongly activated, defining the 'field of mental attention.' Pascual-Leone offered a dynamic view of processing, in particular he suggested that M-capacity (i.e., the capacity of the mental operator or M-operator) increases with age, allowing more complex cognitive performance. It was also suggested that the M-operator has a more important function in 'misleading' than in 'facilitating' tasks (e.g., Pascual-Leone & Morra, 1991).

The growth of M-capacity or M-space is considered to be strictly limited, and to increase maturationally with age. It is defined as the maximum number of independent schemes that can be simultaneously activated in a single mental operation; it grows from 1 at age 3 to 7 at age 15. M-capacity is hypothesized to increase by one schema every two years until a capacity of seven schemes is reached at about the age of 15 years. Hence, the total capacity of any given age is equal approximately to (age - 2)/2. Pascual-Leone did not specify the developmental characteristics of the other operators, except for stipulating that the influence of the inhibition and learning operators are stronger in the second than in the first year of a new M-stage.

The theoretical assumptions have been validated in a number of empirical studies, using different age samples and different tasks. M-capacity has proved to be a good predictor of performance in other cognitive tasks (for details, see Pascual-Leone, 1987; Pascual-Leone & Goodman, 1979). While the theory of constructive operators has prompted a number of studies on the development of memory capacity, there has also been considerable criticism. To begin with, designing tasks that permit assessment of the mental capacity component is not easy and training the child to perform the task is necessary. Pascual-Leone (1970) relied heavily on one particular task to provide a measure of M-space, the compound visual stimulus information task (CVSI). The task requires children between 5 and 11 years of age to react motorically by clapping or raising their hands in response to various visual stimuli (e.g., a square, a red color). After subjects master stimulus-action pairings (e.g., a square calls for clapping, red color calls for raising hands), compound stimuli are presented. For instance, a red square requires subjects to make the two responses that are appropriate for such a stimulus (i.e., both clap and raise hands). The compound stimuli vary in complexity, for example, a child of five-year-old can respond correctly to compound stimuli made up of two stimuli-action sequences, whereas 11-year-old subjects can respond correctly to compounds requiring five stimulus-action sequences.

It should be noted that objections have been raised against Pascual-Leone's conclusion that mental capacity increases with age. Pascual-Leon's model provided a number of predictions to the effect that limits in M-power exert constraints on cognitive performance. However, with increasing age and increasing speed, it might be expected that the amount of space required for the executive actions would decrease. Pascual-Leone (1970) clearly did not account for speed of information processing in complex tasks; in stimulus-action pairings the speed of recognition and execution of these pairings should also increase with age, and thus reduce the amount of capacity required to attend to and execute a single pairing. Finally, in Pascual-Leone's tests of M-space there was systematic confounding with age, because younger children were given fewer stimulus-action pairings to learn and produce in reaction to compound stimuli. Also, different measurement methods were used and produced different age norms.

The evaluation and criticism of Pascual-Leone's original model have led other neo-Piagetian theorists to propose revisions. Case, Kurland, and Goldberg (1982) and Case (1985) have used the term 'executive processing space' to refer to a construct that is similar to Pascual-Leone's M-capacity. Case's notion is that processing capacity has to be shared between storage and processing. Case et al. (1982) have introduced a distinction between the activity of executing an ongoing operation and the activity of storing and/or retrieving the products of such an operation. To examine this hypothesis, Case et al. (1982) used a 'counting span task,' in which subjects are instructed to count the number of items on each card presented to them and then try to recall the series of card totals. The longest series resulting in correct serial recall of totals is the counting span. The argument is that the amount of space required to operate on stimuli functionally decreases with increasing age given more efficient operation of the executive actions. This, in turn, frees up more space for storage of materials and accounts largely for the increase in memory-span performance that is observed. These two components of operating space, and storage space, make up the total processing space. Thus, it is assumed that the relationship between memory span and processing speed reflects a trade-off between operations and storage within a central, total processing space that does not change during the course of development.

The suggestion of a trade-off between storage and processing has been seriously criticized by Halford (1993), who showed that it goes against a number of empirical findings. Other claims have been raised against the use by Case et al. of a battery of tests (i.e., Counting Span, Backward Digit Span, Backward Word Span, Figural Intersections

Test, and Mr. Cucumber) to assess M-capacity of children aged from 6 to 11 years. The use of a battery of four or five tests in order to assess M-capacity difficult and time consuming. Moreover, some tests may be less appropriate for use with young subjects. For instance, Morra and Perchinema (1993, quoted in Morra, 1994) who had a sample of preschoolers in their research, preferred to avoid the FIT and the Counting Span Test, which may cause problems in understanding instructions or lack of motivation in young children. Therefore, these authors only used the Mr. Cucumber and the Backward Digit Span.

All in all, neo-Piagetian conceptualizations of working memory have received much attention in the field, although their validity has been challenged by researchers using different theoretical approaches.

1.3 Development of Short-term Memory Capacity

1.3.1 Development in Knowledge

A great deal of memory research is dealing with memory capacity. There are as many views of capacity as there are models of memory. In most of these models capacity is a central component. Studies of short-term memory capacity increase with age are directly related to memory development. Differences in performance between children and adults on a variety of short-term memory tasks are an indication of capacity increase. Although it is often difficult to assess precisely what researchers of memory mean by the word 'capacity,' there are two general conceptions that may be distinguished: the older 'slots' view implied by Miller's (1956) article on capacity limits and the more recent view, that only a limited amount of attentional energy exists for activating internal units stored in long-term memory (Anderson, 1976; Shiffrin, 1976). This later view is more congruent with the concept of automatic processing. Since Miller (1956) published his famous article, 'The Magical Number Seven, Plus or Minus Two,' suggesting the slots notion, capacity of short-term memory referred to the maximum number of chunks of verbal information that can be held in short-term memory at any given time.

Chunking has been defined as the process of recoding two or more nominally independent items of information into a single familiar unit. Thus, chunking is dependent on knowledge of the stimuli and has to be considered a knowledge-specific strategy (Chi, 1978). In support of this perspective, Simon (1974) reviewed a number of tests on chunk size and concluded the chunk capacity of short-term memory to be in the range of five to seven. Theoretically, chunking should be an important determinant of performance in any task in which the capacity of short-term memory is tested. In view of the characteristics of memory span tasks, many investigators have viewed chunking as a major source of both individual and developmental differences in span (Chi, 1978; Dempster, 1978; Simon, 1974). Increases in memory span with age are presumed to be due to increasingly larger information sequences being encoded as chunks. With larger chunks, the amount of information that can be stored and processed simultaneously increases proportionately.

In comparing short-term memory performance across age groups, Dempster (1978) administered a memory span task involving different series conditions (numbers, consonants, words, nonsense syllables), to 7-, 9-, and 12-year-old children. Developmental differences were obtained when the materials were chunkable, but not when chunking was not possible given the material. The results of the study suggested that the normal age increase in span in middle childhood is due largely to chunking. In a closely related study, Burtis (1982) tested children of 10, 12, and 14 years of age on recall of lists of consonants that were presented in pairs easy-to-chunk, somewhat-difficult-to-chunk and difficult-to-chunk. Principal interest focused on conditions presumed to afford different opportunities for chunking. The results run counter to the chunking explanation of age differences. Burtis' subjects seemed to chunk all of these materials, giving no support to the conclusion that chunking alone could account for age-related increase in recall of consonants. Thus, these findings stand in marked contrast to Dempster's (1978) results. This discrepancy is puzzling and difficult to explain. One possible explanation offered by Burtis (1982) is that in neither of the two studies subjects' prior familiarity with the consonant sequences were determined directly. Probably, both studies in fact used low-familiar stimulus material.

Noting this limitation, Chi (1978) did control this factor by directly assessing the amount of familiarity or knowledge subjects had about stimuli. Six children and six adults, all of whom could play chess to some degree, were given an immediate recall task with digits and an immediate recall test of memory for chess positions. Each subject's knowledge about chess was assessed prior to the memory tests. The children had more knowledge of chess than the adults. They performed more poorly than the adults on a digit-span task, but the results of the immediate recall of chess positions were reversed. The importance of this study lies in the finding that individual estimates of familiarity were clearly related to chunk size and immediate recall, offering strong support for the notion that chunking can play an important role in such performance. However, clear evidence that chunking plays an important role in memory span performance when the stimuli are digits, words, or letters is still lacking. In a careful replication study based on a much larger sample of child and adult chess experts and novices, Schneider, Gruber, Gold, and Opwis (1993) found qualitative differences between experts and novices in that the majority of experts followed a similar plan, starting with the same specific meaningful units, whereas the novices' initial reconstruction patterns were heterogeneous and unpredictable. The conclusion that can be drawn is that chunking, as a grouping together of items on the basis of knowledge, can play a role in mediating some types of memory performance differences. Whether it plays the same role in mediating performance on all tasks of memory span is still unclear.

1.3.2 Development in Focusing Attention

Short-term memory capacity has been proposed by Cowan (1988, 1995) as a function of focus of attention. For example, there can be differences in how much material can be subsumed within the focus of attention at one time. This amount of useful information in the focus of attention can be termed 'processing capacity,' under the assumption that a larger amount of attended information permits a larger amount of information processing. There also can be differences in how efficiently attention is kept focused on the relevant stimuli and tasks. Finally, there can be differences in how well attention can be used to prevent the activation of irrelevant information. That is, there can be differences in the inhibitory function of attention.

In contrast to other authors, Cowan (1988) discards the concept of short-term stores and regards working memory as an activation of long-term memory. Short-term memory is represented as a nested subset of long-term memory. Specifically, the currently activated features comprise a subset of long-term memory, and the current focus of attention is in turn a subset of this activated memory. The theoretical conception of short-term memory in the Cowan (1988) assumption is that transient, activated memory of various types (sensory, phonological, semantic, and motor) may be instances of a common, general storage with many dynamic properties and principles that are common across features types, instead of separate distinct modules, such as Baddeley's (1986) VSSP and AL.

Similarly, attention as processing capacity has been proposed by Just and Carpenter (1992). In their model of memory, there are individual differences in the amount of information that can be in the focus of attention at any one time; they presume that there are differences in the amount of memory that can be activated at any one time. The term 'activation' means 'to keep the memory active by attention.' Just and Carpenter did not consider information that might be activated automatically (without attention).

Daneman and Carpenter (1980) developed a measure of working memory span based on attentional limits. They suggested that adequate performance on memory tasks requires that storage and processing be used together. On each trial a subject must do two things. The first is to comprehend the series of items, and the second is to repeat the last item of each series after the sequence of items is completed. This requires that the subject holds the final items in mind throughout the time that a comprehension task is being conducted. Given adequate comprehension, the number of final items that can be remembered serves as a measure of working memory span. If one individual is found to have a higher memory span than another, the explanation could be that the first individual is able to keep more information in the focus of attention at any one time. That might help the individual to store more information during the memory task, and it also might help the individual to attend to the processing that needs to be done despite the load on memory. This kind of memory span task correlates higher with performance on verbal comprehension and reasoning tasks than does a simple memory span.

As mentioned with the discussion of Piagetian models the notion that attention or processing capacity has to be shared between storage and processing was proposed by Case et al. (1982). They suggested that an important difference between younger and older children is that older subjects can do processing more efficiently, leaving them with more capacity for storing items. The counting span task used by Case et al. (1982) is similar to the span task of Daneman and Carpenter (1980) described above. In the counting span task, subjects count the number of items on each card and then had to recall the series of card totals. Halford, Maybery, O'Hare, and Grant (1994) modified the counting span task in an interesting way. Instead of having to remember the total for each card, a series of numbers was presented first as a memory 'preload.' Next the cards were presented for counting, and then the preload was to be recalled. The results were consistent with other findings in that memory declined as a function of the number of cards counted. If the same processing capacity were shared between the memory load and the counting task, then the cost of counting should be greater in younger children because they would have to expend more processing capacity in order to count. Halford et al. (1994) found that the decline in memory as a function of the number of cards counted was much the same for children who were five, eight, and twelve years old. This, along with other results of this study, suggested that the main source of forgetting was the result of decay of the representation of items in memory, or of interference between preload and number counting, with only a small effect of the difficulty of the processing task that was carried out along with the memory task. Although it is clear that older children use attention better than younger ones, this does not mean that there is a large gain in short-term memory, as would have been expected by Case et al. (1982).

There is a developmental gain in short-term memory ability in these tasks, but it does not seem to have much to do with a developmental change in processing capacity or processing efficiency. It seems that the ability to manage different concurrent streams of information would depend on the ability to switch focus of attention between tasks, or perhaps to split it between tasks. This ability probably is closely related to what Baddeley (1986) has termed the 'central executive' function. However, individual differences in memory span apparently do not have much to do with varying amounts of information in the focus of attention.

Memory performance can also be affected by maintaining one's focus of attention. Maccoby and Hagen (1965) conducted a study with first-, third-, fifth-, and seventh-grade children, using both intentional and incidental memory tasks. On each trial, the subject saw a series of colored cards with a picture of an animal or common object on each card. The task that the child was instructed to carry out (the intentional task) was to remember the sequence of colors. After these trials were completed, a surprise (incidental) memory task was administered. The child's task was to identify which pictures had been presented with which colors. This was incidental in the sense that the children had not been asked to remember the pictures or their relation to the background colors at the time that the cards were seen. Whereas performance on the intentional task increased with age, performance on incidental task actually decreased; it was lower in seventh-grade children than in the younger children. The older children apparently had learned to focus attention on the relevant aspects of the materials to be remembered, and to ignore distractions, more effectively than younger children did. A follow-up study by Hagen (1967) also suggested a tendency among older children to focus more on the relevant information when an additional distracting task was presented. The children had to perceive a deviant low tone within a high-pitched melody, a task to be carried out concurrent with an intentional memory task. It appears, then, that older children are more able to focus attention on relevant information, which may increase the likelihood that this relevant information is encoded adequately and can be recalled later.

Although there has been relatively little developmental research on incidental memory with children, the data that are available are consistent with the conclusion that there is no development of incidental memory. Some evidence has come from experiments with 'priming,' where the attention of the subject is focused on a certain aspect of the task or the materials. Lorsbach and Morris (1991) studied picture recognition and picture recognition priming with 8- and 12-year-olds. Recognition memory improved with development, recognition-priming advantages were developmentally invariant. Generally, there is consistent evidence about an increase in intentional memory and little change in incidental memory. There is a strong suggestion that incidental memory may not change much between the ages of 2 and 20 (Schneider & Pressley, 1997). However, with the deployment of attention, it is assumed that some of the correct answers that a subject produces on a memory task are made possible precisely because the information was held in the focus of attention throughout the duration of the test trial. If a child's attention wanders away from the task-relevant material, fewer correct answers can be produced.

Attention is used not only to activate relevant elements of memory, but also to suppress or inhibit irrelevant aspects, which sometimes appear to become activated automatically and could cause the focus of attention to wander from the relevant information. Hasher and Zacks (1979) suggested that memory may be less efficient when some of the available storage space is taken up by irrelevant information that was not inhibited adequately. They applied this view to changes that occur in aging; Bjorklund and Harnishfeger (1990) discussed how the same principles might be extended to children. They contended that with development, increases in inhibition of task-irrelevant cognition free up proportionately more memory, so that with advancing age more of children's available capacity is devoted to processing of task-relevant information. In support of this position, Harnishfeger and Bjorklund (1993) analyzed intrusions in children's recall of list learning (i.e., recall of words not on the list). There were clear developmental reductions in effects of such intrusions between the preschool years and grade six.

It has been observed that the use of inhibition improves throughout childhood. An experiment by Tipper, Bourque, Anderson, and Brehaut (1989) demonstrates this in an interesting way, using a task known as 'negative priming.' The basic task came from the Stroop procedure in which color words are presented in conflicting colors of ink (for example, the word red may be presented in blue ink). The task is either to name the color of ink or to read the word aloud; the conflicting information slows down the naming and results in errors. The children in the study by Tipper et al. were susceptible to this effect; they were slower and made over twice as many errors as the adults.

For the negative priming procedure, the Stroop task was modified by linking a trial to the next. The irrelevant color word of one trial was used as the relevant color of the next trial. For example, if the irrelevant word was 'blue' on trial n, the relevant color and correct response would be 'blue' on trial n+1. Previous research with adult subjects had shown that this condition results in even slower color naming than for Stroop's original procedure (Hagen & Hale, 1973; Tipper et al., 1989). The explanation offered was that people inhibited responses to the irrelevant word on each trial. In the case of negative priming, the word that was just inhibited in one trial had to be brought back out of inhibition for the very next trial, which presumably took extra time. However, Tipper et al. (1989) found that second-grade children responded differently. Unlike the adults, the children were not slowed down further in the negative priming condition than in the Stroop condition. Probably the children did not carry out as much inhibition, and so neither reaped the reward nor suffered the consequence of this inhibition (Cowan, 1997). It is clear that there is developmental improvement in inhibition and in resistance to interference. It is not clear whether these changes in inhibition are specific to conditions such as Stroop's task, or whether they are just an example of more general developmental changes toward a more efficient control of the focus of attention.

1.3.3 Development in Speed of Processing

It has been observed that with development, speed of processing improves substantially throughout childhood and modestly during adolescence. Compared with young adults, 4- and 5-year-olds typically respond three times more slowly, 8-year-olds respond twice as slowly and 11-year-olds respond 1.5 times more slowly. This pattern of developmental change is found for a wide range of perceptual and cognitive tasks, which has led to the suggestion that a common mechanism may be responsible for age-related change in speeded performance (Hale, 1990; Kail, 1991, 1992). That is, some central mechanism, which changes gradually with age, may limit the rate with which children can process information. This means that with increasing age processes responsible for performance on a particular task such as memory span or word decoding can be executed more rapidly, resulting in superior performance. Kail (1992) and Kail and Park (1994) provided support for the claim that age was positively correlated with a composite measure of memory but negatively with articulation and processing time. Age related effects were greater in early and middle childhood than in late childhood and adolescence, and performance on all memory tasks was more highly correlated with the natural logarithm of age than with unadjusted calendar age.

Processing speed was measured in a number of experiments with adaptations of existing tests. The Coding Subtask Test was taken from the WISC. The experimenter recorded the time required for subjects to complete the test. In the Number Comparison Test (French, Ekstrom, & Price, 1963), and the Identical Pictures Test (French et al., 1963), subjects were timed as they completed the test. Memory span was assessed for digits and letters, and articulation time was measured for words and digits. A path model was explored for a large sample of children and adults who were tested on measures of processing speed, articulation rate, and memory span. It should be noted, that the path from age to memory span remained significant, which means that other age-related variables not related to the speed of processing and articulation rate play a mediating role in the age-memory span relationship. Kail's interpretation of these findings as indicative of increasing structural capacity with increasing age is an important hypothesis for memory research.

1.4 Primacy and Recency

Many memory investigators have adhered to dual-storage models (e.g., Belmont & Butterfield 1969; Frank & Rabinovitch 1974). These models maintain that information first is registered in a short-term memory store. It can then either remain in short-term store for retrieval or it can be transferred to long-term store. It has been found that when people memorize a list of items, usually words, names or digits, their retention is affected in a systematic way by the position an item occupies in the list. The length of the list can vary, and so can the rate at which the items are presented. Experimenters usually use lists between 15 and 30 items long, and present these items at a rate of about one item per second. Immediately after the last item is presented, subjects are asked to repeat as many items as they can. When subjects are free to repeat the items in any order they choose, this is referred to as a free recall task. It has been noticed that items presented at the beginning or at the end of the list are better recalled than items in the middle of the list. The higher probability of recall of items from the beginning of the list has been termed 'primacy effect,' while the higher probability of recall for the last items presented has been termed 'recency effect.' These results have been demonstrated in numerous studies, involving children as well as with adults.

When the results of such studies are depicted in a graph, it will present a 'U' shape showing the relationship between the probability of recall and the position of an item in the series (e.g., Bartz, Lewis & Swinton, 1972; Deese & Kaufman, 1957). The primacy effect is thought to occur because the first few words can be attended to and rehearsed without competition from other items. In contrast, the 'recency effect' is thought to occur because the short-term memory representation of the last few words has not yet decayed much by the time of recall.

Primacy and recency measures provide a general indication of the operation of short-term and long-term memory. According to Greene (1992) in the last thirty years memory researchers have paid much more attention to the recency effect than to the primacy effect. The lack of interest in the primacy effect reflects the feeling that there is a satisfactory account to assume that early items have been rehearsed more frequently than intermediate items and, therefore are more firmly processed in memory. It is likely that early items not only receive more rehearsal, but also the best rehearsal. It has been suggested that it is the type of processing, not merely the number of repetitions which plays a crucial role in producing the primacy effect (e.g., Craik & Watkins, 1973; Greene, 1992).

An explanation for the recency effect came from the two-store model of Atkinson and Shiffrin (1968). We have seen already that this model proposes a distinction between a temporary short-term memory, STM, and a more permanent mechanism, LTM. In the list presentation short-term memory will be filled with the few items that arrived most recently, at the end of the list; these will be the last few items heard, and they will be more readily available and more likely remembered. The items in the middle of the list would no longer be in a short-term memory because they have been displaced by later items. Since the middle items received less rehearsal than early items, these are less likely to be transferred to long-term memory. Therefore, the probability of recall of those items will be low (Schwartz & Reisberg, 1991).

It is well established that the last few items from the list are recalled only from short-term memory. All other items, if recalled at all, presumably are recalled from long-term memory. The first few items are the items most likely to have reached long-term memory, if short-term memory and long-term memory are indeed separate entities. Evidence in favor of the short-term storage view includes, that recency is not influenced by variables with a major effect on earlier items in the list, such as presentation rate. Slower presentation allows for more rehearsal and organization of the items, therefore facilitating recall. However, presentation rate facilitates recall of the items at the beginning of the list and has no effect on the last few items at end of the list (Glanzer & Cunitz, 1966).

Longer lists are usually more difficult to recall, therefore the longer the list the lower the probability of recalling any particular item. However, list length has no effect on recency, the usual recall of the last few items on the list is not affected by list length (Greene, 1992). Waugh and Norman (1965), already argued that, since there is a limit to the number of items that could be placed in short-term memory, increasing list length should simply lead to more items placed in long-term memory, but not affect the number of items in short-term memory.

The way to eliminate recency effects should be to delay recall and ask subjects to recite in the meantime materials different from those being used in the experiment. This activity should have no effect, except on recency, because the distracter task should prevent the subject from maintaining the last few items in short-term memory. Results show that an actively interpolated task between the list presentation and recall does not appear to interfere with the recent items on the list, but may influence recall of other items elsewhere in the list. For example, Murdock (1965) required subjects to sort a deck of cards while they were hearing a list of words for immediate free recall. Murdock varied the difficulty of this sorting task. This manipulation of difficulty significantly affected recall of early items but had no influence on the magnitude of the recency effect. Similarly, Baddeley and Hitch (1977) showed that recall of early items was impaired by requiring subjects to copy digits while they were seeing a list of to-be-recalled words. However, the recency effect was again not influenced by this manipulation.

An interesting extension of the literature on recency effect can be found in studies using multicategory lists. Watkins and Peynircioglu (1983), demonstrated the existence of up to three simultaneous recency effects, each of which was comparable in magnitude to a recency effect under conventional conditions. They gave their subjects a 45-item list that contained three sublists of 15 items each. The three sublists were combined in one list. Subjects were asked for immediate free recall, but were cued to recall a particular sublist first, second or third. Recall for each of the three sublists showed a recency effect that was as large as would have been expected if the sublist had been presented alone.

Studies to demonstrate recency effect in retrieval from long-term memory were also conducted. In one study a standard free recall procedure was used in which subjects were presented with lists of unrelated words separated by a distracter activity, and required to recall the words after a 20 second delay. The delay time was filled with backward counting between the final word and free recall. A clear recency effect was reported (Bjork & Whitten, 1974; Tzeng, 1973). Other studies have demonstrated recency effect over much longer periods. Baddeley and Hitch (1977) showed that when rugby players attempted to recall the teams they had played against earlier that season, they showed clear evidence of recency, as in an immediate free recall task, with the crucial factor being the number of interpolated games rather than elapsed time.

Analyses of developmental primacy and recency effects generally tend to support the conclusions reached in the adult literature (Belmont & Butterfield 1969; Frank & Rabinovitch 1974).

Sarver, Howland, and McManus (1976) used a modification of a digit span task. The task was administered to children in the first, third, and fifth grade. The subjects were required to verbally recall serial digits presented at various rates. The subjects were tested individually in an immediate recall task. Although they were not asked to recall the numbers in order, inspection of the data revealed that all children chose to recall the digits in an ordered form. In the next trial, there was a short delay period. The subjects received a 20 seconds interpolated task. After this task, the subjects again were asked to recall the digits. The results showed that older children recalled more digits than younger children, but only in the delayed and not in the immediate condition. Immediate recall tasks demonstrated a general primacy and recency effect for all grades. Delayed recall data reflected an age-related primacy effect. As in the literature on adults, the interpolated tasks depressed the recency effect. Older children demonstrated more primacy effect. There was also an age-related primacy effect in the immediate recall task.

The study supports conclusions generally arrived at in developmental studies of memory, namely that older children perform better than younger children in delayed recall tasks. Thus, age differences are considered a crucial factor in memory tasks. Interpretation of these results centers mainly on the lack of rehearsal among young children. Rundus and Atkinson (1970) stated that the relationship between amount of rehearsal and correct responses in free recall tasks of verbal material for adults is positive. Some other factors may be responsible for children's poor performance in serial recall tasks, such as inefficient retrieval strategies. Work on children's memory for visual materials has shown that there is primacy effect only in older children, but that a recency effect is found in both older and younger children.

Hagen and Kail (1973) studied primacy and recency effects in two groups of children 7- and 11-year-olds. They used a distraction condition and a facilitation condition. In the latter, subjects were asked to think about the pictures during a 15-sec delay period. In the distraction condition subjects were asked to count aloud. The results showed that overall recall did not differ at either age level; recall for recency was found in both older and younger children, while recall for primacy improved for the older age level only. The facilitation in recall occurred mainly for the items near the primacy portion of the serial positions. In the distraction condition, the most striking finding was the disappearance of age differences in recall, the serial position recall of the older subjects was very similar to that of the younger subjects.

Primacy effects among children in the absence of rehearsal raises various questions. Siegel, Allik, and Herman (1976) have shown that the primacy effect exhibited in young children of ages 6 and 7 is a function of the spatial rather than the temporal component of a task. The superior performance on the primacy as well as recency positions arises from additional cues provided by the spatial positions, rather than from rehearsal. This conclusion was derived by mismatching temporal and spatial positions during presentation. Exactly the opposite conclusion was drawn by Spitz, Winters, Johnson, and Carrol (1975), using the same paradigm with 8-year-olds. Spitz et al. found that the primacy and recency effects derived from cues provided by the temporal order of presentation. Perhaps the difference in the two studies lies in the method of response used. Siegel et al. (1976) applied a probe technique, while Spitz et al. (1975) used a free recall task. A serial probed recall has been widely used to study short-term memory in children. The task was introduced by Atkinson, Hansen, and Bernbach (1964), and tends to sustain children's attention by presenting a sequence of seven or eight pictures to the subject, one at a time. As soon as a card is presented, it is laid face down in a row in front of the subject. After all cards have been shown, a probe card is presented, and the subject's task is simply to turn up the card that matches the probe.

The existence of primacy effects in young children cannot be attributed entirely to the same processes as in adults and older children. Adults can manifest primacy effects as a result of both rehearsal and spatial or temporal cues, whereas children's primacy effects arise only from the spatial or temporal cues. This difference can perhaps explain why primacy effects are not a consistent finding in young children recall. The fact that primacy effects can arise from two separate processes in adults may explain their elevated overall recall performance in a serial probed recall task.

An interesting study was conducted by Keeton and McLean (1976). The study was based on Jensen's (1980) suggestion that children from inner-city and suburban environments encode digit series for recall through different intelligence-related processes. They compared two groups of children. One group was chosen from a school in a downtown area. The other group was drawn from a residential suburban area. Children were tested individually during two separate sessions. They were presented with two lists of digit series. The analysis of the data indicated that different recall patterns characterized the responses of the two groups. The inner-city children showed a different pattern for recency than for primacy as the length of the series increased. Suburban children performed at a superior level on the recall of average span length series of four and five items, but the inner-city children recalled significantly more of the latter items of longer series. In the suburban group recency recall decreased with series of eight- and nine-digit length. However, the average number of primacy and recency pairs recalled was not significantly different in the two groups. The evidence cannot be interpreted as contradicting the assumed universality of primacy and recency effects; rather, the application of alternative strategies for the selection and organization of sequentially presented information can explain the quantitatively equivalent but qualitatively somewhat different performance of the two groups of children in this study. This explanation may be more plausible than one in terms of intellectual and cultural deficit, proposed by other researchers.

1.5 Forgetting

People are vulnerable to forgetting things. Even a small piece of information may be quickly forgotten. The earliest experiments on forgetting were carried out by Ebbinghaus using himself as a subject. The experiments, which he conducted on himself, involved learning lists of 13 nonsense syllables to the point of being able to repeat each list twice in order without error. He recorded the number of repetitions he needed to learn the lists and then tested his retention for these lists after various delays. He then recorded the number of repetitions he needed to relearn the list. Ebbinghaus always found that recall was imperfect on the first recall trial, indicating that forgetting had occurred. He was able to estimate the amount of forgetting by counting the number of trials it took to relearn the list to the original level; the more forgetting, the more trials would be needed to relearn the list. Ebbinghaus established that the rate of forgetting is initially rapid and then slows down following a function that is approximately logarithmic. The rate of forgetting of meaningful material was found to be similar to the rate for nonsense syllables, but 'saving' (i.e., reduction in time to relearn the material completely) was generally greater for meaningful material. Ebbinghaus (1885) conceived of forgetting as a quantitative fading of memory that follows a nonlinear function of passage of time. This relationship could be expressed as (retention/forgetting) = k / (log time)^{C}, with k and c referring to constants. This function specifies that the rate of forgetting is greater shortly after learning than it is later.

Many possible reasons have been suggested for forgetting information from short-term and long-term memory. The most prominent theoretical frameworks that have been suggested are memory decay and memory interference.

1.5.1 Decay Theory

Memory decays while it is stored, so it is not available at the time of retrieval. Decay theory assumes that memory traces are eroded by the passage of time, or according to Ebbinghaus, 'The persisting images suffer changes which more and more affects their nature.' It is presumably not time itself that causes forgetting, but the neural events that inevitably take place over time in any living organism. Barnes (1979) in a neurophysiological study with rats provided some evidence for the explanation of decay in terms of neural processes. Long-term potentiation as an increase in neural responsiveness can be brought about by prior electrical stimulation. The data on long-term potentiation suggest that the decay of responsiveness involves changes in synaptic strength. Thus, there may be a direct relationship between the concept of strength defined at the behavioral level and strength defined at the neural level. The idea that memory traces simply decay in strength with time is one of the common explanations of forgetting.

Classical studies of forgetting have been carried out by Brown (1958) and Peterson and Peterson (1959). Brown showed subjects a set of one to four consonants that had to be read aloud. Immediately after the presentation of consonants, a set of five pairs of digits was shown. Subject were required to read them aloud as well. Then the experimenter requested recall of the consonants. Subjects' recall of the consonants was quite poor, especially when more than two consonants had to be remembered. Brown intended to show that recall can be improved by inserting an unfilled delay interval between the presentation of consonants and presentation of digits. This was to allow subjects to rehearse the consonants before introducing the distracter task and to reduce the vulnerability of the stimuli to forgetting.

Peterson and Peterson (1959) explored the time course of forgetting under conditions of distraction. The major finding is a rapid drop in performance when subjects engaged in a distracting activity. The authors allowed subjects to rehearse during the period between presentation of to-be-remembered items and the beginning of the distraction task. Extension of the period of rehearsal improved the subjects' performance, but did not affect the rate of forgetting; that is, rehearsal did not affect the slope of forgetting function, it affected only the asymptote at which the curve finally flattens out. Murdock (1961) showed that the slope of the forgetting function is related to the amount of information that subjects have to remember. When subjects were required to remember only one item, the rate of forgetting was lower and the eventual asymptote higher than when recall of three items was required.

Brown (1958) and Peterson and Peterson (1959) interpreted their results in terms of a decay process in memory. Decay means that forgetting takes place as a result of the automatic fading of the memory trace. The onset of this decay can be postponed by means of rehearsal of items. If rehearsal is suppressed by introducing a distracter, the trace will start to decay. The rate of this decay process is equivalent to the slope of the forgetting function. When recall drops to the asymptote, the decay process is complete.

It has been mentioned already that a distracter task prevents rehearsal and leads to more forgetting. The more difficult the distracter the more effective it is in eliminating rehearsal (Kroll & Kellicutt, 1972). Another aspect of distracters that has been examined is their degree of similarity to the items that have to be remembered. Similarity is particularly important when the same sensory modality is addressed. A distracter task is much more effective if it is presented in the same (visual or auditory) modality as the list items. Pellegrino, Siegel, and Dhawan (1976) presented subjects with either triads of words or triads of pictures as to-be-remembered materials. When an auditory verbal distracter task was used, recall of pictures was higher than recall of words. When the distracter task involved visual processing this advantage for pictures was eliminated. Presumably when subjects are trying to remember words, they rely on verbal rehearsal, and this process is particularly impaired by having to perform an auditory task. When subjects are trying to retain pictures, they rely on visual pictorial rehearsal, and this form of rehearsal is then impaired by processing visual distracter stimuli. Distracters dissimilar to the to-be-remembered material, but within the same modality, have also been examined. Reitman (1974) had subjects remember a list of five words and used a nonverbal tone detector task as a distracter. A significant amount of forgetting after 15 seconds of nonverbal distraction was found.

There have been several challenges to the interpretation by Brown (1958) and Peterson and Peterson (1959). One challenge is to their estimation that information is forgotten over a course of 15-20 seconds. The forgetting process may be much more rapid than they believed. Muter (1980) argued that forgetting from primary memory (short-term memory) could be assessed more accurately when people do not expect a recall test, because they are less likely to engage in processing that contributes to secondary memory (long-term memory). Muter (1980) conducted an experiment where subjects knew it to be unlikely that they would have to recall the items. On every trial, subjects would see a set of three letters and then a set of three digits. Subjects were required to count backward from that three-digit number. For most trials subjects were not required to recall the letters; only on a few trials recall of the letters was required after the period of counting backward was completed. On those trials the results showed dramatic forgetting; after as little as 2-4 seconds the proportion of letters recalled was very low. Muter concluded that low expectancy of testing reduced strategic processing and led to more rapid forgetting than the Brown-Peterson estimation.

To assess the effects of expectancy of testing, Sebrechts, Marsh, and Seamon (1989) introduced three standard encoding strategies (i.e., semantic, acoustic, and reading tasks). Subjects had to remember a set of three words. In a semantic orienting task, subjects had to indicate whether each word was animate or inanimate. In an acoustic condition, subjects had to indicate whether there was an 'e' sound present in each word. In a reading task, subjects merely had to read each word aloud. The results replicated Muter's very rapid forgetting phenomenon under low recall expectancy. Recall was affected by the task that subjects had to perform on the words; memory was best for the words read aloud, followed by the semantic orienting task, and lowest on the acoustic task. The significance of the findings by Muter (1980) and by Sebrechts et al. (1989) lies in their challenge to the rate of forgetting. They did not call into question the cause of forgetting, which Brown and the Petersons believed to be decay.

It is hard to doubt that memory does not decay; whatever the actual storage mechanism may be. However, the rapid loss of information may merely mean that such information has not been stored, and the most dramatic reason for its failure to be recalled may well be the interfering effects of other material that has been learned.

1.5.2 Interference Theory

Forgetting can also be explained in terms of interference. Memories that are similar to each other somehow interfere with each other and thereby lead to forgetting. The fact that interference plays an important role in forgetting has been documented empirically. Muller and Pilzecker (1900, quoted in Greene, 1992) tested two groups. The experimental group learned a list, then learned a second list, and thereafter had to recall the first list. The control group learned a list, then rested with no particular activity, and thereafter recalled the list. The experimental group generally recalled fewer items on the list than the control group. These results have been interpreted in terms of an interference effect that interrupts the recall of the subjects in the experimental group. Accordingly, forgetting occurs because new learning works against or interferes with existing knowledge.

Much of the original research in interference has involved learning of paired associates, where the interest has focused on how the learning of one list of paired associates would impact on the memory for another list with different associates for the same terms. Interference can be understood as of the amount of activation that is spent to activate a memory structure. The idea is that when subjects are presented with a stimulus like 'dog,' activation will spread from this term to all of its associates. There is a limit on the amount of activation that can be spread from such a source. The more associations to a source, the less activation is available for any particular memory structure. Anderson (1974) illustrated these ideas by asking subjects to memorize 26 facts of the form 'a person is in a location.' Some persons were paired with only one location, and some locations with only one person. Other persons were paired with two locations, and other locations with two persons. Before beginning a memory test, subjects studied the material and were able to recall all the locations associated with a particular type of person (e.g., teacher) and all the persons associated with a particular location (e.g., park). The interest was focused on the speed with which information could be retrieved. The results showed that it is more difficult to maintain multiple associations to the same stimuli. Subjects were faster in recalling items involving a specific person associated with one specific location, and slower in recalling items with multiple associations. Anderson concluded that the more facts associated with a concept, the slower retrieval of any one of these facts.

An alternative hypothesis was postulated by Tulving, who argued that at least some forgetting is not simply due to a weakening of the stored trace. A number of experiments involved the utilization of retrieval cues (hints or clues that can be used to evoke an item that has been learned), but cannot spontaneously be recalled. In the first of these studies, Tulving and Pearlstone (1966) presented subjects with lists of words from a number of different semantic categories, for example, birds, vegetables and animals. Half the subjects attempted to recall the words in the absence of any cue, while the other subjects were cued by being given the category names. The authors observed that subjects given the category names recalled more words than those given no cues. Subsequently, when the latter subjects were given the category cues, they recalled a number of words they had previously not mentioned.

Tulving and Psotka (1971) attempted to demonstrate the importance of retrieval cues in forgetting. Subjects were given lists of 24 words to learn. Each list comprised four words belonging to six conceptual categories. After the presentation of each list, the subjects attempted non-cued recall of the words from that list, a test of original learning. After the subjects had learned their last list and tried to recall it, they were asked to provide free recall of all the words from all the lists they had seen, a second test of non-cued recall. Finally, the subjects were given a test of cued free recall of all the words from all the lists, in which they were given the names of all the conceptual categories used in the lists. The results indicated that performance on the overall non-cued recall test is a typical example of interference, with the number of words forgotten from a list being directly related to the number of other lists interpolated between the learning of the list and the recall test. Subjects tended to forget whole categories, but when they were given the names of the categories of the various lists and attempted cued recall, recall was restored to about its original level, and showed clearly that the subjects' difficulties on the non-cued recall task were not due to a complete loss of stored information. Tulving indicated that the interpolated trials or interference impaired performance, and that forgetting has occurred as a result of removing retrieval cues, rather than from loss of information from memory. When relevant cues were provided by the experimenter, the interference effect disappeared.

The study of interference phenomena has become widespread in explaining forgetting. Interference is assumed to cause forgetting in two ways. First, prior learning can retard new learning; this impact of old learning on new is labeled proactive interference or PI. It happens when an event is forgotten due to interference from similar earlier events. The other way is the impact of new learning on the old, termed retroactive interference or RI.

1.5.3 Proactive Interference

Proactive interference refers to instances in which earlier learning interferes with later learning. The classic experimental demonstration of proactive interference came from a study by Underwood (1957) in which his subjects showed substantial forgetting of a list of nonsense syllables over a 24-hour delay. Since it seemed unlikely that his subjects went home and mugged up other interfering nonsense syllables in the interval, it was not clear where the forgetting might originate. Underwood used the same undergraduate subjects repeatedly, suggesting that proactive interference from earlier experiments might be a source of forgetting. He plotted the amount of forgetting as a function of the number of nonsense syllable experiments the subjects had taken before. Underwood found a clear result; the greater the number of prior experiments, the greater the forgetting. He wrote to various colleagues asking if they had similar data. For each of the experiments he received, he plotted the amount remembered after 24 hour as a function of prior lists. These results confirmed the effect of proactive interference; the amount forgotten over a 24 hours interval increased substantially with the number of prior lists learned. However, not all of the change could be attributed to forgetting through interference. Warr (1964) pointed out that as people learn more lists they become quicker at memorizing. A consequence is that subjects have more exposure to the items on their first few lists. When this is taken into account the size of the decline with previous lists is much less than Underwood (1957) estimated, though it is still quite substantial, as Keppel, Postman, and Zavortink (1968) showed.

Underwood and Postman (1960) suggested that forgetting may be due to interference between words within the language. For example, words that are common within the language will tend to have strong associations with other words, causing such high-frequency words to be forgotten more rapidly than less common low-frequency words, which are assumed to have weaker associations. Underwood and Postman (1960) tested this prediction in a series of experiments. The results indicated that rate of forgetting appeared to be unrelated to the frequency of a words, or when nonsense syllables were used, to the frequency with which the constituent letter pairs occur in English.

Underwood and Ekstrand (1966) suggested that the lack of an effect of language habits may be attributable to a tendency for proactive interference to be much less prominent when the interfering material is learnt under distributed practice. They showed that distributed practice did indeed lead to less proactive interference. However, these results also raise difficulties for explanation. One is why a single individual list should be forgotten, given no prior massed learning of similar materials that might interfere. It also has been suggested that lists of words or nonsense syllables learned under laboratory conditions of massed practice may have even less relevance for normal learning than was expected.

1.5.4 Retroactive Interference

Retroactive interference refers to the interfering effect of later learning on recall. In the standard paradigm, the experimental group learns a list of items, followed by another list, and then has to recall the first list. The control group learns one list, and then rests during the interpolated learning period before recall. McGeoch and MacDonald (1931) provided an early illustration of retroactive interference. They had their subjects learn a list of adjectives until they could recall it perfectly. Following this, their subjects spent ten minutes either resting, or learning new material varying in similarity to the original list. As the similarity of the interpolated material increased, there was a drop in the amount retained from the original list. Thus, the nature of the new materials being presented proved to be crucial. Most damaging to the memory of the original list was the learning of synonyms of the original adjectives. Other adjectives also affected performance. Lists of numbers had far less effect; subjects who had memorized lists of three-digit numbers could recall three times as many of the original list of adjectives as those who had memorized synonyms in the intervening period. Slamecka (1960) had subjects learn sentences by heart. He presented the material on two, four, or eight trials, followed by either a rest period or a period during which the subjects had four or eight trials learning another equivalent text. The results showed that the amount learned is a function of the number of initial learning trials, and the amount forgotten is a function of the number of interfering trials.

There is one area in which retroactive interference effects have been explored in considerable detail. It has become known that the testimony of witnesses to a crime is subject to disruption as a result of interference from subsequent questioning. This phenomenon has been explored in great detail by Loftus (1977), and subsequently by many other investigators. In one study Loftus (1977) had subjects watch a film of a car crash. Subjects were later asked various questions about the accident, including how fast the cars were going when they hit each other. All the subjects were asked the same question except that the word 'hit' was replaced by 'smashed,' 'collided,' 'contacted,' or 'bumped.' The particular word used influenced the speed estimation of the cars, with the word smashed evoking the highest average speed, and contacted the lowest. A week later, subjects were asked if there was any evidence of broken glass. Those who had been tested using word smashed were more likely to report incorrectly the presence of broken glass.

In a subsequent study, Loftus (1977) presented a series of slides to her subjects showing a car accident in which a pedestrian was hit at a crossing. A green car was driving past the accident without stopping, after which a police car arrived and a passenger from one of the cars involved in the accident went for help. After having seen this, the subjects were asked a series of questions, one of which referred to a 'blue' car that drove past the accident. When after 20 minutes, the subjects were asked about the color of the car that had driven by without stopping, subjects given the false information were more likely to choose blue rather than the correct color of green.

There is no doubt that distortion can be readily induced in subjects by such misleading information. It has been found that the wording of the questions can have great influence on the responses. Loftus (1975) asked some people 'Do you get headaches frequently and, if so, how often?' These subjects reported an average of 2.2 headaches per week; other subjects were asked the same question but with the word 'occasionally' substituted for the word 'frequently.' These subjects reported an average of only 0.71 headaches per week.

On the basis of these results Loftus and her colleagues concluded that the memory trace is actually distorted or destroyed by subsequent information, rather than obscured by it. They concluded that later information can overwrite established memories, or that information learned subsequently can substitute parts of the memory trace of the previous information.

Loftus' research has stimulated many attempts to demonstrate that the original information is still in memory, but just not easily accessible. In a subsequent study, Bekerian and Bowers (1983) showed that, under certain circumstances, the original information had not been destroyed, and that given appropriate conditions, it could be recovered. They pointed out that the best method of questioning subjects in the Loftus paradigm was to probe for information by taking the subject systematically through the incident, starting with questions about the prior circumstances and systematically moving forward. Under such circumstances there is a much better chance of reinstating the framework in which the material had first been experienced. Bekerian and Bowers (1983) carried out a study in which they used Loftus' material, followed by misleading material inserted into the subsequent questions. The study then went on to test for memory distortion. One group was questioned in random order, while the other group was questioned in the order in which the incidents occurred. Subjects tested in a random order showed the standard distortion effect, while those tested in the order of occurrence of the incidents did not show distortion. It appears, then, that the initial experience had been overlain by the misleading information, but not destroyed as Loftus had previously concluded.

1.5.5 Release from Proactive Interference

Proactive interference seems weak if testing occurs soon after learning, but this interference grows with the passage of time. Retroactive interference, on the other hand, is maximal right after learning the second list (that is, the list that produces the interference). Retroactive interference diminishes with time. Both forms of interference are maximized when the stimulus words on the two lists are very similar. Both forms of interference also increase when the quantity of interfering material is increased (Greene, 1992).

Since interference is dependent on similarity between the stimulus words, it should be possible to get rid of proactive interference by changing the nature of the target items after the first few trials. This was investigated by Wickens, Born, and Allen (1963) in an experiment in which one group of subjects received four trials where the to-be-remembered items were lists of three consonants. Performance dropped on each subsequent trial. Another group also received four trials. However, on the first three trials the to-be-remembered list consisted of digits. On the fourth trial, these subjects had to remember a list of three consonants. On this fourth trial, performance was almost perfect. This indicates release from proactive interference. Wickens (1972) found that changes in the nature of the list items (such as from digits to letters) resulted in the most complete release. More subtle changes in meaning (such as changing from words with a pleasant connotation to words with an unpleasant connotation) could result in partial release. In general, the amount of release from proactive interference that one finds when shifting between semantic categories depends on how similar these categories are; more release is found when one switches from a category to a very dissimilar one.

The hypothesis that release from proactive interference reflects an enhancement of encoding processes was tested by Gardiner, Craik, and Birtwistle (1972). The subjects in this study went through four trials. The first three trials involved recall of words from a single semantic category. On the fourth trial, there was a shift in the nature of the materials, but the subjects were unlikely to realize this on their own. On the first three trials, subjects might be recalling names of garden flowers (e.g., carnation, wallflower, and gladiolus) and on the fourth trial wild flowers such as dandelion, buttercup, and bluebell. One group of subjects went through these four trials and exhibited clear proactive interference on the second, third, and fourth trials. A second group went through the first three trials. At the beginning of the fourth trial, they were told that there would be a shift in the nature of the material (garden flowers to wild flowers). When asked for recall on the fourth trial, these subjects exhibited release from proactive interference.

These results are compatible with an alternative explanation in terms of encoding processes. These subjects knew what the switch would be at the beginning of the trial, and this knowledge can have influenced how well they encode the items. A third group received information after the presentation of the critical sequence, but before recall. The crucial question is whether subjects can use this new information to help them discriminate between the target item and earlier potentially interfering item. Subjects were in fact successful in using this cue, they showed substantial release from proactive interference, even though they presumably had not noticed whether the flowers were wild or not during learning. Apparently, subjects can use the release cues during the retrieval processes.

Release from proactive interference may have interesting practical implications. Gunter, Berry, and Clifford (1981) suggested that proactive interference effects might occur in television news bulletins, where the viewer is presented with a succession of items of news that may or may not be thematically similar. They suggested that retention should be best if similar items were separated rather than being blocked. Subjects watched a series of four TV news items and then attempted to recall these either immediately or after a delay. In the control condition, the items were all from the same category, either all home news or all foreign news. There was a clear built-up of proactive interference, with each successive item being less well recalled. In the experimental condition, the fourth item came from the other category as the previous three items. Results indicate that release from proactive interference occurred, with the item from the new category being recalled better in both the immediate and the delayed condition.

The conclusion that can be drawn from these controversies among theories has been stated by Baddeley (1997) 'The study of forgetting is an area of considerable theoretical importance that has been recently neglected. It almost certainly needs theoretical modeling skills of greater sophistication than were applied by interference theorists; but such skills will need to be combined with careful empirical research if they are to throw light on this crucial aspect of memory' (p. 185). One may conclude that neither decay theory nor interference theory has offered a complete explanation of the phenomenon. The decay theory based on the Brown and Peterson's conjecture was meant to explain forgetting in short-term memory. Empirical evidence of decay was used to distinguish between a short-term store and its susceptibility to rapid forgetting, and a long-term store. Interference theory explains forgetting as a result of interference from the many similar pieces of information we may have stored in our memories. Such interference can arise as a consequence of our inability to distinguish between the information we want to remember and that what we do not need.

1.6 Development of Forgetting

Early research on children's forgetting was started when Vertes (1913, 1931, quoted in Schneider and Pressley, 1997) explored children's retention and forgetting of verbal materials using the word-pair method. Vertes tested children of 6 to 18 years of age on immediate retention followed by two delayed tests at intervals of one day and one week. More than 80% of the materials were recalled on the immediate memory test. After an interval of one day the rate of forgetting was about 8% for the younger subjects and not more than 3% of older children. After one week, children older than 10 years of age were able to remember more than they had on the previous tests. It is clear that Vertes' results did not conform to the basic results of Ebbinghaus' experiments. Three possible explanations were given by Vertes. First, the method of word pairs differs from Ebbinghaus' approach. Second, forgetting does not follow Ebbinghaus' formula. The third possible explanation is the most important, namely that forgetting may not be the same for children as for adults. This explanation was based mainly on results obtained in previous experiments. Compared to adults, children needed a larger number of repetitions to learn a series of items for the first time and their rate of forgetting seemed less than that of adults. However, there were large discrepancies between sets of data, Ebbinghaus forgot more information in one hour than what has been found with adults in other studies.

Brunswik, Goldscheider, and Pilek (1932; quoted in Schneider & Pressley, 1989) conducted experiments on verbal memory of children 6 to 18 years of age. In the study, younger children received nonsense syllables, one-syllable words, and numbers as learning materials. Older children received paired concepts, poems as well as a combinations of numbers and nonsense syllables. Children of 6 to 13 years required more repetitions to learn nonsense syllables than words or numbers. With increasing age, fewer repetitions were needed to learn the same type of materials. No age differences were found in learning meaningful materials. However, results of delayed recall with meaningful materials were similar to the findings reported by Vertes (1913, 1931) that higher scores were obtained after one week than scores obtained at immediate recall. As in Vertes' work the retention of older children and adolescents appeared to be lower than that of younger children. Brunswik et al. (1932) also administered tests of memory span. Meaningful memory span was assessed by asking for recall of a picture story of a Christmas Eve, with instructions asking for reproduction in sequential order and learning 24 pairs of real objects. The major findings were that memory span for meaningful materials continues to develop into adolescence, whereas memory span for meaningless materials reaches its peak by the age of 12 years. The disparate growth curves that were obtained for different memory functions based on scores from about 700 subjects, corresponded closely to those reported by Vertes (1913, 1931) who found linear and steep rises in performance from 6 to 11 years of age.

Other results are consistent with the apparently paradoxical outcomes of Vertes, indicating improvements in performance after fairly long intervals. However, literature on the development of forgetting is so sparse, that it is still unclear whether or not forgetting from long-term memory varies with age. Rogoff, Newcombe, and Kagan (1974) found no difference in forgetting rate among children 4 to 6 and 8 year old using recognition tests that were administered one week after acquisition. Fajnsztejn-Pollack (1973) examined recognition memory for pictures in 5- to 16-year-old children using retention tests that were administered between 2 and 49 weeks after presentation. Performance declined across this interval but there were no age differences in forgetting rate. Morrison, Haith, and Kagan (1980) reported two experiments involving four age levels. In the first experiment they found that forgetting decreased with age when a recognition test was administered 24 or 48 hours after acquisition. In a second study Morrison et al. (1980) administered a yes-no recognition test asking children whether or not each word had been presented during the acquisition session. In line with the hypothesis, older and younger school children performed almost equally well on recognition of previously presented materials. Morrison et al. (1980) concluded that 'rate of decay of information is invariant across age' (p. 483). Sophian and Perlmutter (1980) conducted a study to examine the extent to which age differences in the encoding and retention of information in memory contribute to improvement in preschool children's recall. A serial recall task was used with two age groups of preschool children. They found that the older children showed greater improvement in recall over trials than younger children. The recall of the two groups declined over the testing sequence, but the rate of forgetting was more or less invariant.

Paris (1978) presented a list of categorically related words to second- and sixth-grade children. Multiple recall tests were used to detect children's forgetting rates and retrieval strategies. Children in both grades remembered many new words on later recall trials that they had not remembered on the first trial. The proportion of new words recalled and the retrieval characteristics of these words were similar in both grades.

Effects of distraction on five- and eight-year-old children's performance decrements in short-term memory tasks were examined by Hale and Flaugher (1977). Tasks of three difficulty levels were administered via projection of slides onto a screen. In the middle of the screen there was a circle surrounded by several square 'windows.' There were four, five, or six windows depending on the experimental condition. Appearing in these windows were line drawings of common objects (e.g., boat, kite, or house). A total set of 8 objects was used for the four-stimulus task, 10 were used for the five-stimulus task, and 12 were used for the six-stimulus task. On a given trial the subject first viewed a group of stimuli in the windows, then was shown one of those stimuli in the center circle, the subject task was to point to the window in which that stimulus had appeared. The tasks were presented to children at ages five and eight years, to determine age differences in performance decrement. The results show that the performance decrement was roughly equal for the two age groups regardless of the task difficulty, and performance was well above chance under all conditions.

Intentional remembering and forgetting has been studied among children as well as adults. In an experiment by Foster and Gavelek (1983) subjects were presented with a list consisting of a series of pictures each of which was followed by a cue either to remember (R) or to forget (F) the item. At the end of the list subjects were asked to recall as many R-items as they could. The ability to do so, relative to the exclusion of F-items constitutes an index of subject ability to remember and forget intentionally. It was found that adults were able to differentiate between R- and F-items with consistently low F-item recall. In a similar developmental study conducted with normal children, it was found that as early as the fifth grade children could differentiate between R- and F-items, also with low F-item recall.

Eliminating interference from irrelevant information in memory has been studied to understand the increasing ability of the child to respond to task-relevant stimuli and to disregard irrelevant stimuli. In a directed forgetting paradigm numerous studies have found that adults spontaneously adopt strategies eliminating interference from irrelevant information (Bjork, 1972). Howard and Goldin (1979) used two groups of kindergarten children. One group was given prior cues concerning the information to be forgotten. The other group was given a regular directed forgetting task in which the cue occurred following the presentation of each to-be-forgotten item. The precued group had no difficulty disregarding the irrelevant information. In the other condition there was interference with recall of the to-be-remembered items.

In the same line, Bray and Ferguson (1976) tested first-grade children in a directed forgetting task in which the forgetting cue occurred with some of the trials in a sequence. There were frequent control trials with no forgetting cue. On some trials a forgetting cue appeared after presenting an item, while on other trials it occurred before presenting an item. The children remembered the items presented after a forgetting cue more accurately than the items given before a forgetting cue. Bray, Justice, and Zahm (1983) investigated developmental changes in the use of strategies to eliminate interference from irrelevant information in memory. Two experiments were conducted. The subjects in the first were 7-, 9-, and 11-year-old children and those in the second were adults. Subjects were presented with two sets of pictures, on some trials there was a cue to forget the first set and to remember the second set. The results indicated that seven-year-old children did not utilize a cue to forget and nine-year-old children were only partially successful at doing so. By eleven years of age, children had no difficulty using forgetting cues effectively and disregard irrelevant information. Adult subjects used a sophisticated rehearsal strategy in order to retain the to-be-remembered items.

The general conclusion of these studies is that forgetting rate is similar for all age levels. Older children only recall better than younger children. Young children can disregard irrelevant information in memory if given a cue before information is presented, while older children can adopt sophisticated strategies that minimize interference from the to-be-forgotten material. The effect of distraction on children's recall is similar across ages.

1.7 Summary

Several models were proposed to explain memory functioning. Short-term memory capacity as indexed in memory span has been found to increase with age. It is not clear that such increase in memory span can be interpreted as enlargement of some biologically determined capacity. Even if developmental increases in short-term memory capacity prove to be largely predetermined, this may have nothing to do with increases in neurological structure. The case seems to be strong that the increasingly efficient execution of operations with development is due in part to developmental increases in processing speed. Such increases may be a consequence of changes other than structural increase in retention capacity. There are developmental improvements in the focus of attention and control of inhibition that may account for increase in functional short-term capacity. Factors such as changes in the persistence of memory and the rate of memory search seem likely to be strongly rooted in maturation. Frequently studied factors, such as changes in knowledge and strategy use, have been found to improve with experience and maturation. The results obtained with children suggest that relative slowness in brain processes (Baddeley 1986; Cowan 1994; Kail & Saulthouse 1994) may make it difficult to carry out effectively many of the strategies that adults use, and this may lead to memory loss before the mental task at hand is completed.

Research on forgetting carried out by Ebbinghaus suggested that forgetting follows a logarithmic function, beginning rapidly and then slowing down. Subsequent studies have shown that this is not always the case, with some materials appearing to be lost at a steady linear rate. The explanation of forgetting remains an open question. Interference between memory traces may be an important factor, but whether this involves the destruction of one trace by another, or simply reflects competition between traces at retrieval remains a rather unresolved issue. However, powerful interference effects do occur, with impairment of recall of information due to prior learning (proactive interference) as well as later learning (retroactive interference).

Chapter 2

Development of Memory Strategies

2.1 Introduction

Memory strategies include processes of encoding and retrieving that are related in a complex way. Strategies that are used to assist in memory tasks are termed 'mnemonic strategies.' Common guidelines such as writing down the information, or ignoring a potential distracter are considered mnemonic strategies. Procedures to store information have been termed encoding strategies; they are deployed during study of material in preparation for subsequent recall. Memory strategies are mental operations that individuals perform on events that they experience, including storage and retrieval of the information. These operations are conceived to work according to deliberate, controllable plans (Naus & Ornstein, 1983). Strategies are used to help acquire information, such as study skills children learn in school, to help them master new materials or to learn certain games. Strategies are also used to retrieve information from long-term memory. Individuals have various choices of processing methods or 'strategies' to encode or retrieve information. For example, consider a child's means to solve a simple arithmetic problem such as '7+3.' If the child knows the answer, the fastest way to solve the problem is usually to retrieve it from long-term memory. If the child does not know it, he may use his fingers.

Memory strategies exist together with other cognitive operations and can be influenced by many other factors. Contemporary models of memory propose distinctions between major features of memory; for example, the two-store model has made a distinction between structural features and control processes (e.g., Atkinson & Shiffrin, 1968). Structural features are said to be composed of a sensory store, a short-term store and a long-term store. Information is guided through the memory structure by control processes, that are assumed to be under the conscious control of individuals and employed to aid remembering. The development of these control processes has been found to begin as early as three years of age (Wellman, Ritter, & Flavell, 1975), and they appear in a stable or spontaneous form by the age of 13 years. Some earlier cross-cultural research (Cole, Gay, Glick, & Sharp, 1971; Wagner, 1974) has shown that the development of control processes is culture specific. Certain cultures seem to have developed techniques for remembering that are not found universally, and that may be particularly useful for the type of information to be remembered on a given task.

2.2 Use of Strategies in Young Children

There has been extensive research on children's use of memory strategies, much of it with school-age children. Research in strategy development has focused as much on what children can do as what they cannot do. It was recognized that many young children could not benefit from a strategy even when it was demonstrated to them. The implication was that children do not have the conceptual ability to use that strategy. Flavell (1970) has introduced the term 'production deficiencies' to refer to children not spontaneously using a strategy but being able to experience some benefit from its use when instructed. That is, their 'deficiency' is in terms of producing the strategy, not in benefiting from its use. Miller (1990, 1994) has suggested a term of 'utilization deficiency' to describe the children's failure to benefit from using a strategy. Unlike production deficiency, there is little or no enhancement of performance when children use a strategy.

Memory strategies are typically evaluated with tests of recall. Free recall is the most typical kind of memory test, with children having to retrieve information in reaction to a general request (e.g., tell me the names of your friends). Prompts or cues can also be provided with questions. This type of tests is referred to as cued recall. Age differences in free recall tests are usually large, with young children showing low levels of performance. When specific cues are provided, substantial increase in levels of performance occur. The interpretation of this finding is that young children are not very good at searching their memories. Young children do not possess or do not use memory strategies either to acquire information or to retrieve what information they have acquired. However, their memory performance can be quite good given specific prompts or cues. Very salient prompts during encoding do seem to affect memory. Requiring four- to five-year-olds to sort to-be-learned lists into semantic categories enhances memory of the material (e.g., Lange & Griffith, 1977). It has been found that even three-year-olds will use retrieval cues to aid their recall. Ritter, Kaprove, Fitch, and Flavell (1973) examined three-to five-year-old children by giving them six pictures of people (for example, a soccer player) and six small toys (for example, a soccer ball). Each of the six toys was related to one of the six people. Each person was hidden in one of six houses in front of the children. They were then shown a 'twin' of each person and asked where to find his or her 'partner' and were told that they could use the toys to help them remember the correct locations if they wished. Under these very explicit conditions, a majority of the preschoolers used the toys as retrieval cues (for example, placing the soccer ball outside of the house containing the soccer player). Only 20% of the three-year-olds used retrieval cues, while 75% of five-year-olds used toys as cues in this situation. Thus three-year-olds were not using a retrieval strategy unless the conditions made its use highly obvious or when they were specifically instructed to do so (Bjorklund & Douglas, 1997). Strategic behavior that involves the use of external memory cues has also been found among young children. Heisel and Ritter (1981) asked three- to nine-year-old children to hide an object in one of 196 containers, arranged in a 14 x 14 grid, in such a way that they could remember the location. An effective strategy would be to hide objects in distinctive positions, such as the corners of the display, which is what children five years of age and older did. The youngest children, did not use such techniques, although some children attempted to hide the objects in the same location on all trials, which reflects the use of external cues to hide things.

When preschool children are presented with a list of objects, pictures, or words to learn, they typically can recognize some of these items later, but they cannot recall them (Perlmutter, 1984). That stimuli can be recognized, suggests that the children have encoded the material, that was presented for learning; that they cannot recall them suggests, that preschoolers are not very proficient at searching their memories and at self-prompting about events that they have experienced. When preschool children are instructed to memorize, their memorization behavior can be changed. Baker-Ward, Ornstein, and Holden (1984) had children either in a 'play' condition or in an 'instruction' condition. Subjects in the play condition were given no indication that they would have to remember information later on. Children in the instruction condition were informed that they could play with the toys, but they should do all they could to remember a specified number of the toys. Subjects in this condition played significantly less than subjects in the play condition; they were more likely to name the to-be-remembered objects or look at them intensely. These differences in the frequency of memory-related behavior as a function of experimental condition were found at all age levels and increased with age. However, as far as recall is concerned, these memory-related behaviors affected only the performance of the six year-old children in the study.

When children are prompted with cues, their recall improves. Sodian, Schneider, and Perlmutter (1986) presented four-and six-year-olds with 16 toys that could be classified according to taxonomic and color criteria. The subjects in a 'sort-and-remember' condition were told to code items into memory by putting them into groups that they felt belonged together. Subject in a 'play-and-remember' condition were given no instructions specific to sorting, but rather were told that they were allowed to play with the items before they would be given a memory test. All subjects categorized more according to taxonomic classification than according to color. The provision of category cues at recall had a more positive effect than provision of color cues. An important finding was that there was significantly more categorical clustering during recall in the sorting condition than in the play condition. A significant memorizing versus playing effect in favor of the memorizing condition was obtained, but only with the 4-year-old subjects (Schneider & Pressley, 1997).

As this brief review indicates, it is not appropriate to classify preschool children as strategic, although they do indeed implement what appear to be intentional, goal-directed behavior. Sometimes these strategies work, and other times they are what Wellman (1988) described as 'faulty strategies,' which means that sometimes young children use strategies that do not help remembering. While noting that preschoolers are not as deficient in strategic abilities as once believed, one should not overlook the fact that their mnemonic abilities are substantially less than those of older school-aged children, who display strategies in a wide range of situations including school-like and laboratory tasks.

2.3 Development of Rehearsal Strategy

Although there are many encoding strategies, a few have received much more attention from developmental psychologists than have others. According to Cowan (1997), most mnemonic strategies would fall under 'rehearsal' or going over the information in one's mind. A verbal repetition of to-be-remembered material is considered a strategy of memorization, which is available in the context of deliberate memory tasks.

Rehearsal has been studied intensely by memory researchers. The interest perhaps was motivated by the critical position of rehearsal in multi-store models (Atkinson & Shiffrin 1968, 1971), levels-of-processing models (Craik & Lockhart, 1972), as well as Flavell's (1978) work on mnemonic strategies. Levels-of-processing theorists consider rehearsal as a specific version of effort that can be devoted by an individual in a list learning task. This explanation came from experiments in which subjects received a list of items to read. After a short period subjects were asked to recall as many as possible of the items. Performance is a function of rehearsal processes that subjects have practiced during the time interval between presentation and recall.

Craik and Watkins (1973) distinguished between two types of rehearsal, maintenance rehearsal and elaborative rehearsal. Maintenance or rote rehearsal means going over the information as presented, to keep items in short-term memory by recycling or repeating them over and over, without thought about the meaning. Subjects using this type of rehearsal are expected to perform poorly on recall tasks. The second type of rehearsal, elaborative rehearsal keeps the information available for further analysis and processing at deeper levels, and permits forming new, meaningful connections between items to be remembered. This should result in better retention.

Flavell, Beach, and Chinsky (1966) described the development of rehearsal among children of five, seven, and ten years of age. The children prepared for serial recall of picture lists. Immediately after presentation and during a 15-second delay, children were observed by an experimenter, who was trained to identify lip movement corresponding to the target words in order to record the frequency of rehearsal. The authors reported age-related increase in both the amount of rehearsal and levels of recall. Only very few 5-year-olds displayed multiple-item rehearsal strategies; in contrast, most of the oldest subjects cumulatively rehearsed the list items. More specifically, 85% of the fifth-graders produced some cumulative rehearsal in comparison to only 10% of the children in kindergarten. Furthermore, within each grade level children who exhibited more rehearsal were generally higher in recall than those who rehearsed less. Based on these results, Flavell and his associates concluded that verbal rehearsal serves as mediator in recall and that the more children rehearse, the more they can remember.

Investigations based on overt rehearsal techniques permitted more detailed developmental information. The overt rehearsal method, requires subjects to recite all items aloud, making direct measurement and evaluation possible. Ornstein, Naus, and Liberty (1975) studied rehearsal of third, sixth, and eighth graders. The subjects were instructed to rehearse serial lists of items aloud, with five seconds interval between the presentation of each item. The typical age effects for serial recall were obtained. Older subjects both recalled more items and exhibited a primacy effect. The overt-rehearsal procedure did not reveal age-related differences in the frequency of rehearsal, younger children rehearsed just as much as older children. Differences were found in the style of children's rehearsal. Younger subjects rehearsed in a more passive way, because they repeated each word with only one or two other words during the interstimulus interval. In contrast, the older children rehearsed the target word with many other words during the interstimulus interval, a style that has been labeled active, or cumulative rehearsal. Ornstein and his colleagues argued that older subjects' active rehearsal accounted for both their greater recall and the primacy effect that was obtained in the data. Thus the primary developmental changes in rehearsal concern style rather than frequency.

Clear evidence that the difference in rehearsal between third graders and older children is a production deficiency has been described by Naus, Ornstein, and Aivano (1977). They trained third graders to use three-item rehearsal sets. These third graders displayed the primacy effect typical to older children, in addition their recall was approximately at the level of grade-six children. Still, although training young children increases their levels of recall, age differences are rarely eliminated entirely (Ornstein, Naus, & Stone, 1977). A thorough analysis of the third-graders' rehearsal revealed more rigidity in the younger subjects than in older children, with younger children tending to form a single three-item set following each item and repeating it until the next item was presented. Older children tended to vary their three-item sets more. It seems that the essential differences between the memorization process of younger compared to older children are qualitative rather than quantitative. Passive one-word memorization strategies are replaced by cumulative rehearsal strategies, with the number of different items in a rehearsal set reaching three or four (Ornstein & Naus, 1978). These results were complemented by Kunzinger's (1985) longitudinal study of overt rehearsal. Seven-year-old children were presented with lists of words and tested for recall. After two years they were tested again. There was an increase in rehearsal set size with development (from 1.7 to 2.6 items). Guttentag, Ornstein, and Siemens (1987) observed a comparable increase in rehearsal set size of children between 8.5 and 9.5 years of age.

The relevant data suggest that developmental increase in active, cumulative rehearsal plays a crucial role in age differences in free and serial recall tasks. The question is the degree to which cumulative rehearsal facilitates encoding of information versus its retrieval. Perhaps only active rehearsal transfers information from short-term memory to long-term memory. Alternatively, active rehearsal makes it easier to retrieve information later on. An experiment that compares recognition memory with recall testing, can provide an answer to this question, because recognition tests reduce retrieval demands, at the same time providing information about what is available in long-term memory. If developmental differences occur on recall tests, but there are no differences on recognition tests, it can be assumed that the material was encoded into long-term memory at all age levels, but that younger children experience retrieval difficulties that are somehow linked to their failure to use cumulative rehearsal. However, if there are also developmental differences in recognition, this could be taken as evidence that different repetition strategies produce different encoding, because the amount and quantity of information in long-term memory depends on the strategy used to code such material. Naus, Ornstein, and Kreshtool (1977) conducted an experiment in which third and sixth graders learned a word list and then took either a recognition or a recall test. Consistent with their prediction, there were significant developmental differences in recall, especially, due to differences in recall of items at the onset of the list. No age differences was found in the recognition data.

Another possibility has been suggested, namely that the overt cumulative rehearsal strategies build interitem associations, which make it easier to retrieve items during recall. Compatible with this assumption, the effects produced by active rehearsal strategies are considerably reduced when to-be-learned material is presented in a blocked fashion (e.g., by category). Presumably, salient list structure produces interitem associations automatically (Ornstein, Naus, & Miller, 1977). An additional mechanism that may account for the retrieval benefits produced by cumulative rehearsal is the self-testing that is part of cumulative rehearsal; thus cumulative rehearsers have practice with recall more than passive rehearsers before the actual recall test takes place (Schneider & Pressley, 1997).

2.3.1 Young Children's Rehearsal Deficiency

Generally, memory strategies become more efficient with age over the middle-childhood years. The development of rehearsal strategies is consistent with this argument. Studies of the content of older children's rehearsal sets reveal that better recall occurs when items are produced in groups that include both recent items and items from earlier list positions, that is when children use cumulative rehearsal. It has been found that older school children and college students include items that they liked when they cumulatively rehearse sets of words (Cuvo, 1974). One possible explanation of cumulative rehearsal is that motivational factors play a role. Early studies assessed the effects of extrinsic rewards on children's strategy use. Kunzinger and Witryol (1984) gave seven- and eight-year-old children sets of words to rehearse and remember. Some words were identified as ten-cent words. Children would receive a dime for every one of these words they remembered. Other words were designated as one-cent words. Children would receive only a penny for each of these words they recalled. Children rehearsed the ten-cent words twice as much as the one-cent words. These findings indicate that young children can be motivated to produce a more active rehearsal strategy and recall according to extrinsic incentives.

A second possible explanation of older children's cumulative rehearsal is related to the development of semantic memory, with older children having more concepts and interconceptual associations to trigger the use of strategies. Tarkin, Myers, and Ornstein (quoted in Ornstein & Naus, 1985) examined the impact of knowledge on the rehearsal activities of young children. They presented eight-year-old children with lists of words that varied in familiarity and meaningfulness. The children displayed age-typical rehearsal (i.e., less than two items per rehearsal set) for meaningless items. In contrast, the learning sets for meaningful items contained more than three items. Memorization behavior with meaningful materials was comparable to the behavior of 11- to 12-

year-olds with normal word lists. Familiarity with the material seems to be an important determinant of the use of more efficient and effective rehearsal procedures.

There is yet another possibility why young children do not employ cumulative rehearsal strategy spontaneously, namely the mental effort required to do so which strains their cognitive functional capacity. That is, strategy use has a cost in terms of mental effort. Young children may use so much of their limited resources executing the strategy that they do not retain sufficient mental capacity to perform other aspects of the task efficiently (Case, 1985). One technique that has been used to study this hypothesis is the dual-task procedure, which is based on the simple idea that it is difficult to do two things at once. In addition to rehearsing to-be-remembered items overtly, subjects simultaneously perform a key tapping task. Mental effort is reflected by the interference on key tapping produced by cumulative rehearsal. Interference can be measured as the difference between normal tapping during a baseline period when simultaneous rehearsal is not required and tapping during rehearsal. Guttentag (1984, 1985) conducted a series of experiments, in which second, third and sixth graders were instructed to employ the overt cumulative rehearsal strategy and to perform the motor task simultaneously. All subjects were able to do this with no age differences in memory performance. There were, however, significant differences in the degree of interference experienced. Motor performance was clearly disrupted more during rehearsal among younger children than among older children. Even more interesting, there were no age differences in interference effects when children were instructed to rehearse passively. Based on these findings Guttentag reported that age differences in spontaneous use of cumulative rehearsal strategies may in part be due to the effort required of young children to execute complex strategies.

An interesting study conducted by Ornstein, Medlin, Stone, and Naus (1985) confirms the interference effect detected by Guttentag, and provides more support for the mental effort needed by younger grade-school children to execute a cumulative rehearsal strategy. Ornstein et al. demonstrated that the efficiency of second-grade school children's cumulative rehearsal improved considerably when they provided these children with additional visual cues as they rehearsed, that is when previously presented items continued to be visible (thus, reducing the pressure on working memory to hold previously presented material in consciousness). The visual cues helped them to cumulatively rehearse almost five items per set in the cumulative rehearsal instruction compared to about three items per set with instruction, but without pictorial support.

These findings led to the conclusion that a critical developmental difference concerns children's inclination to use a particular strategy rather than their ability to use it. That is, younger children are production-deficient in that they have access to rehearsal strategies that would facilitate their performance, but fail to implement these when it would prove beneficial to do so.

The general conclusion is that there are age-related increases in both the amount of rehearsal and the level of recall. According to Flavell (1985) rehearsal is an 'illdefined group of memory strategies.' Young children five- and six-year-olds often respond with a single word in response to each item in a serial list of words. Almost all seven- to nine-year-olds children repeat an item several times while it is in view. Most ten-year-olds use cumulative rehearsal to learn serial lists. However, more complex rehearsal tactics are manifested by older subjects. Almost all college-age subjects use cumulative rehearsal for primary list items followed by the last few items on the list.

Observational methods have been the main methods used to investigate rehearsal. The results indicate that use of cumulative rehearsal has positive effects on recall. Even children in the first-grade can use cumulative rehearsal strategies when they are instructed to do so, but spontaneous use of cumulative rehearsal among first-grade children is infrequent. Procedures and stimulus material can be modified to make production-deficient children more active with regard to cumulative rehearsal strategies. High motivation for learning, and familiar meaningful materials can evoke children's cumulative rehearsal. The most important difficulty for young children seems to be the mental effort required to execute the strenuous processes of cumulative rehearsal.

Recent research on rehearsal strategies revealed an interesting result, namely that words and text are better learned if practiced as lyrics and songs. For example, Calvert and Tart (1993) reported experimental and naturalistic studies suggesting that poems, songs, and rhymes are better learned if they are practiced compared to rehearsal of ordinary text for a similar number of times. Such work is potentially important given growing interest in the cognitive mechanisms mediating the memory of poems, songs, and rhymes (Rubin, 1995).

2.4 Development of Organization Strategies

Next to rehearsal other frequently studied encoding strategies involve the organization of stimulus materials into meaningful categories that can mediate learning and recall. Development of organizational strategies has been studied with pictures and word lists usually containing items that can be categorized. The items are often selected, using age-appropriate norms, from familiar categories (e.g., fruit, animals, and utensils). Depending on the age of the subjects, three to twelve categories are used, each containing three to five items (Murphy & Puff, 1982). Organization of the materials during output is presumed to reflect processes that occurred during memorization. Results have indicated that subjects who demonstrate high levels of clustering in their recall generally remember more than subjects who demonstrate lower levels of clustering (Bower 1970).

Clustering in recall most often has been measured in developmental studies using the adjusted ratio of clustering (ARC) formula provided by Roenker, Thompson, and Brown (1971) and the ratio of repetition (RR) measure (Bousfield, 1953). The ARC score provides a measure of clustering at recall independent of the number of items correctly recalled. The RR reflects the number of intracategory repetitions as a proportion of the total number of items recalled on a trial. For both of these measures, values close to 1.00 represent almost perfect organization and 0.0 indicates random responding. The

RR measure is more appropriate when different levels of recall are expected for various groups of subjects, because this measure has been found to be independent of absolute levels of recall (Murphy, 1979).

Developmental studies on semantic grouping during free recall have reported more clustering with increasing age. The inference was that older children organized input more in preparation for recall. Moely, Olson, Halwes and Flavell (1969) indicated that only 10- to 11-year-old children organized significantly above chance. Such findings suggest that organizational strategies develop later than more passive rehearsal strategies, and probably even a little later than cumulative rehearsal. That is because semantic relations between items are complex and demand more mental activity than rehearsal.

It seems that young children are reluctant to use an organizational strategy in so-called sort recall tasks. In a study conducted by Salatas and Flavell (1976a), first-grade children were given 16 pictures, which could be organized into four distinct categories (e.g., animals, clothing, toys, and tools). After naming each picture and each of the four categories, the experimenter placed the pictures randomly on a table in front of the children. The children were then told that they would be asked to remember the pictures later and they should put the pictures together in a way that would help them to remember. A free recall test was given 90 seconds later. Despite instructions that would lead children to physically sort the pictures into categories, only 27 percent of the children did so. Other studies using similar instructions conclude that even 8-year-olds often fail to organize items into meaningful categories. Older children are more likely than younger children to categorize items according to their meaning and to use such organization during study. As a result, they produce higher levels of clustering and recall more items (Best & Ornstein, 1986).

It has been found that when lists contain highly associated items even young children can use organization. When young children (first graders) were asked to group items, they rely primarily on associative relations while older children (seventh graders) rely on categorical relations in forming their groups (Bjorklund & deMarchena, 1984). In studies examining categorical organization in recall memory, the above chance levels of clustering often observed in the protocols of young children have been attributed to the use of associative rather than categorical relations (Frankel & Rollins 1982). These authors expected that young children would show output clustering as a function of associations between individual items within categories rather than a relationship to the taxonomy itself. Frankel and Rollins (1985) constructed four lists that varied in terms of categorical relatedness (high versus low) and associativity (high versus low). They reported relatively high levels of performance for fourth- and tenth-grade subjects when either associative strength or categorical relatedness was high. In comparison, for kindergarten children, levels of organization were high only when highly associated items served as stimuli; a high or low degree of categorical relatedness had no influence on their performance.

Schneider (1986) demonstrated the development of organization strategies. Second-and fourth-grade children were given a recall task, with categorizable pictures serving as stimulus material. Subjects were permitted to do anything they wanted to learn these items. Four types of lists were used. One list contained high related-high associated items, the other three lists were composed of high related-low associated, low related-high associated, and low related-low associated items, respectively. The results indicated that the fourth graders employed much more categorical sorting than did the second graders; the fourth graders also clustered more at recall and recalled more items. There was more clustering in lists with highly associated items. There was an interaction between age and item association recall in the clustering data; low associativity penalized young children compared to older subjects. There were no differences in clustering low and high associative items for the older subjects. In general, all correlations between clustering at study, clustering at recall, and recall were significant. In a similar study, Hasselhorn (1992) confirmed Schneider's results.

Other studies have provided additional support to the notion of associativity. Frankel and Rollins (1982) found that in recalled material that could be categorized semantically, young children produced categorizable material in pairs, while older subjects remembered longer strings of categorizable words. This pattern of recall indicates that young children's recall of categorizable information is more associative than categorical.

In the last 20 years, researchers have emphasized the role of children's knowledge base in the use of strategies (Bjorklund, 1985, 1988; Chi, 1985; Ornstein, Baker-Ward, & Naus, 1988). For example, children are more apt to use a cumulative rehearsal strategy and show high levels of category clustering (Bjorklund & Zeman, 1982) when more highly familiar versus less familiar sets of items are used as stimuli. Generally, theoreticians in this area propose an interaction between children's knowledge and their use of strategies. Ornstein, Naus, and their colleagues (Ornstein & Naus, 1985; Ornstein et al., 1988) have suggested that younger children's attempts at sort recall tasks are stimulus driven in that strong associative interitem relations automatically induce some semantic encoding. They assumed that during grade school, children experience enough memory tasks to discover strategic information, like the utility of exploiting categorical and associative relations between items. Even preschool children may display strategic functioning for highly familiar information. In contrast, Bjorklund and his colleagues (Bjorklund, 1987; Bjorklund & Jacobs, 1985; Bjorklund & Zeman, 1982) have suggested that relations among items in semantic memory become more strongly established with age, and that deliberate, categorical organization memory strategies are not typically found until adolescence when they can be activated with relatively little expenditure of mental effort.

Bjorklund's (1985) main assumption was that with increasing age the interitem relationships in semantic memory become more elaborate and can be activated relatively automatically. This assumption was based on Case et al.'s (1982) hypothesis that with development the functional mental space becomes larger, in part because of increasingly automatic access to relevant knowledge. With the increase in efficiency of knowledge access, and hence an increase in functional capacity, older children can deal with to-be-learned material at a more abstract, taxonomic level. Bjorklund contended that conscious strategies, when they eventually do occur, are in fact stimulated by the knowledge base. He argued that at some point subjects will notice the cluster structure of their output and in turn recognize the gains associated with clustering. This would stimulate 13 to 15 year-old children to use clustering.

There are two positions about the age at which category organization becomes a deliberate memory strategy. The knowledge-base position claims that strategic organization is typically not observed before the age of twelve, while from the metamemory position (to be discussed in chapter 3) the emergence of such a strategic competence is apparent in most children at about age ten. Studies touching on this controversy reveal rather consistent differences regarding methodological details. The advocates of the knowledge-base position typically use a free-recall task, manipulating category typicality and interitem associations. In contrast, the adherents of the metamemory position prefer the sort-recall paradigm and assess subjects' task-specific metamemory. Bjorklund, Muir-Broaddus, and Schneider (1990) argued that the inconsistencies in children's use of categorization strategies can be attributed to differences in task difficulty. Sort recall tasks are easier to handle for young children, because they usually have sufficient time to encode the stimulus items. Also the instructions often bias children to form meaningful groupings of items, which is not the case in most free-recall (non-sorting) experiments.

Most of the research on strategy development discussed has emphasized processes that facilitate rote recall of words or pictures; strategies such as elaboration and studying complex materials are acquired later. Elaboration involves an association between two or more items. Research on elaboration has been mainly concerned with effects of paired-associate learning on recall. In paired-associate tasks subjects learn pairs of unrelated items and are asked upon presentation of one item to recall the other. Research has indicated that children do not spontaneously generate and use elaboration strategies until adolescence (Pressley & Levin, 1977). Strategic activities involved in extracting meaning from text and understanding complex information are rarely observed in elementary school children. Schneider and Bjorklund (1997) note that the qualitative developmental trend found between sixth grade and twelfth grade parallels the pattern found for rote-recall memory strategies between first and sixth grades.

Young children do not spontaneously group even high-associated items on a meaningful basis, they need specific instructions or training. Instructions to young grade-school children to sort during study seemed to overcome a production deficiency in using organizational information in lists (Schneider, Borkowski, Kurtz, & Kerwin, 1986). Two possible explanations were proposed for young children's failure to use organization strategies in learning clusterable lists. One explanation is input failure, that is failure to group materials in a clear way during encoding. The other explanation is failure to retrieve categorizations constructed at encoding (Lange, 1978).

Most likely, the locus of strategic failure to use organization is during acquisition. In fact, the intentional use of organization during encoding has been demonstrated by the consistency of the significance of relations between children's input organization and recall (Frankel & Rollins, 1985; Lange & Griffith 1977; Schneider, 1986). This conclusion has been supported in a number of studies that used multiple regression procedures to estimate effects of organization at input and organization at output on memory performances in children of various ages (Schneider, 1986; Schneider et al., 1986).

There are many studies on the use of external memory aids to retrieve information. For example, Kobasigawa (1974) presented lists of categorizable items to 6- to 11-year-olds to learn for subsequent free recall. He also presented pictures to the children during learning and recall. Each picture represented one of the categories on the test (i.e., a picture of a zoo for animals). As predicted, 6-year-olds generally did not use these retrieval cues at testing, but 8-to 11-year-olds used the cues fairly consistently.

It is difficult to disentangle the impact of encoding and retrieval processes on subjects' recall clustering in sort recall tasks. Even when important strategy efforts at input have not been realized, older grade-school children strategy competence remains powerful enough to initiate an effective categorical retrieval strategy. Developmental changes in category organization during retrieval were studied by Hasselhorn (1990) with a memory task where subjects had to encode in a non-categorical serial way. A procedure was developed to minimize the possibility of categorization at input and to control for age differences in item acquisition. Hasselhorn tested second- and fourth-grade school children on non-categorically learned lists. Subjects unexpectedly received either serial or free recall instructions. The results indicated that fourth graders' recall exceeded second graders only in the free, but not in the serial recall conditions, while also higher levels of clustering were observed for fourth graders in the free recall condition. The grade effect on free-recall data was eliminated when the influence of categorical clustering statistically was partialed out. The pattern of results was interpreted as demonstrating fourth graders' strategy competence in activating category knowledge during retrieval. These results are similar to previous findings regarding clustering during encoding (Frankel & Rollins, 1985; Schneider, 1986). As noted by Flavell, Miller, and Miller (1993), much of what develops in the area of memory retrieval consists of the ability to search the long-term-store system in an intelligent, systematical, flexible, exhaustive, and selective way, whatever the retrieval problem at hand demands.

The conclusion can be drawn that there are developmental changes in the efficient use of retrieval strategies. The spontaneous use of simple retrieval strategies such as the use of external associative cues can be observed in kindergarten or early grade-school years (Wellman, 1985). The development of efficient retrieval processes continues with increasing age. Complex retrieval strategies, such as reorganization of the stored information combined with exhaustive search and thorough evaluation (e.g., Salatas & Flavell, 1976b) do not enter the strategy repertoire until the late grade-school years or adolescence.

Much of the improvement with age would seem to be due to increasing efficiency in the use of organizational strategies, with the pattern of skill acquisition following a similar function for all children. However, the results of cross-sectional studies of strategy acquisition have been based on group comparisons. Theoretically, improvements at the group level could bias individual estimates, because the performance that has been attained in a group could be due to some children making great progress whereas others show little progress.

This issue was explored by researchers involved in the Munich longitudinal study on the genesis of individual competencies (Schneider & Pressley, 1997; Schneider & Sodian, 1991; Schneider & Weinert, 1995). In the study a traditional sort-recall task was presented to a sample of about 200 children five times within the period of about 10 years when the children were 4, 6, 8, 10 and 12 years old. There were several interesting findings: (a) the group means for sorting during presentation of the stimuli, clustering during recall and recall performance conveyed the impression of a gradual increase in strategy use and recall performance over the age range under study; (b) the mean indices of organization for sorting during presentation and clustering during recall, as a function of age, were in accord with the outcome of most cross-sectional studies described earlier; (c) the correlations between encoding strategies (sorting), retrieval strategies (clustering) and memory performance in the sort-recall task increased with age. Intercorrelations among strategy and performance measures were low for the 4-year-olds (r = .24), they were of moderate size for the 6-year-olds and increased up to about .70 for the 10-year-olds (with a slight drop at age 12 that was due to ceiling effects in strategy use). Thus, the analyses at the group level indicate that the longitudinal findings were in line with correlational outcomes in cross-sectional studies; that is, strategy use appears to become increasingly effective with age.

If it is true as suggested by the group level data that the majority of children follow the same developmental paths, then we would expect high stability over time in test-retest correlations. Accordingly, the rank orders of the children should then remain relatively constant; that is highly strategic children at age 4 maintain their relative superiority as strategists at age 10, and vice versa. The results were not consistent with this assumption. Stability for recall was generally low, ranging from .16 over a 6-year period to .39 over a 2-year period (Schneider & Weinert, 1995). Stability for sorting and clustering was even lower, indicating long-term instability over time. This may indicate that there is considerable change in the relative position of individual children in the sample between measurement points.

Sodian and Schneider (quoted in Schneider & Pressley, 1997) followed up the low stabilities for the strategy and recall variables. If individual children change their relative position in the sample considerably between measurement points (as indicated by low stability), the model of gradual improvement that fits the group data well does not seem to hold for strategy acquisition in individual children. More than 80% of the subjects were jumping between chance level (sorting scores < .30) to perfection (sorting score > .80) at subsequent measurement points. Only 8% of the subjects followed a pattern of gradual improvement in strategy acquisition. There was also variation in the age at which children first showed evidence of strategy use, and many children who did so at some measurement points 'lost' it subsequently and 'rediscovered' it later on. Thus, some of the instability in strategic behavior over time can be explained by individual variation in the age of strategy discovery: Children go from chance levels of sorting to near perfection, but they do so at different points in time. Their patterns of strategy development showed leaps and U-shaped curves. These findings seems consistent with other evidence of multiple and variable strategy use in children for a wide range of tasks (Siegler, 1995).

2.5 Summary

Research on memory strategies has focused on rehearsal and organization. Verbal repetition of to-be-remembered material or rehearsal strategy has been found to develop with increasing age. Young children 5- and 6-year-olds often rehearse single words on a serial list of words. Most of 10-year-olds use cumulative rehearsal to learn serial lists. Spontaneous use of cumulative rehearsal is infrequent among first-grade children.

The development of organizational strategies resembles the development of rehearsal strategies. Interitem associativity and category familiarity can play a role in determining recall. These variables generally influence input and output organization. Sorting at input has been found even with very young children. However, spontaneous and effective use of organizational strategies is typically not found until 10 or 11 years of age (Schneider, 1986).

The accumulated evidence suggests that both the increased knowledge base and the development of intentional use of organizational strategies contribute to developmental improvements in learning of categorizable lists.

Chapter 3

Metamemory Development

3.1 Introduction

The concept of metamemory, or people's awareness of their own memory processes, has been known as early as 1907 when Kuhlmann investigated subjects' knowledge about their memory for pictures of familiar objects. Half a century later, several investigators became interested in individuals' 'feeling-of-knowing' that is, of evaluations that information was stored in long-term memory but was not accessible (Brown & McNeill, 1966; Hart 1965). The potential importance of modern research on metamemory was anticipated by some experimental psychologists, including Tulving and Madigan (1970) when they called for knowledge of memory knowledge.

The term 'metamemory' was first introduced by Flavell (1971; Flavell & Wellman 1977). Flavell used the term 'meta' to indicate the higher-level aspect of the phenomenon. Thus metamemory refers to the knowledge that individuals have about memory processes. Flavell's conception of metamemory was very broad, including knowledge of all aspects of information storage and retrieval, as well as memory functioning, limitations, difficulties, and strategies. Flavell and Wellman's taxonomy parsed metamemory into two main categories, sensitivity and variables. The sensitivity category included knowledge of when memory activity is necessary (e.g., awareness that a particular task in a particular setting requires the use of memory strategies). The variables category was divided into three subcategories: (a) person characteristics relevant to memory, (b) task characteristics relevant to memory, and (c) potentially applicable memory strategies. An example of a person variable is the person's mnemonic self-concept, including knowledge about all personal attributes that influence memory of information. Task variables include factors that make a memory task easier (e.g., familiar materials, high interitem associations) or harder (e.g., long lists, short study time). Strategy variables include knowledge about encoding and retrieval strategies, including rehearsal, organization, and clustering.

Flavell and his colleagues argued that metamemory categories and subcategories are not independent of one another, but rather overlapping and in interaction. Different individuals do not always solve a problem equally well (i.e., there are person by task interactions) and the strategy chosen to solve a particular problem depends on person as well as task characteristics (i.e., there are person by strategy by task interactions). Flavell's theory was that metacognitive knowledge, metacognitive experiences, and cognitive behaviors constantly interact. Thus, metamemory is viewed primarily as enhancing memory performance. Flavell also argued that, like other knowledge, metamemory may be inaccurate, may not be activated when needed, and may not be beneficial when activated. These metamemory 'failures' are especially likely to occur in younger children. A number of studies have supported Flavell's theory. His early research led to the conclusion that a great deal of metacognitive development is completed by age eight or nine (e.g., Kreutzer, Leonard, & Flavell, 1975).

A rather new conceptualization of metamemory was developed by Brown (1978; Brown & DeLoache, 1978). Her focus was on the competent information processor, who possesses an efficient 'executive' that regulates cognitive behaviors. The executive is aware of the system's capacity limits and strategies. More important, the executive monitors success and failure in memory behavior. This regulatory component of metamemory is responsible for selecting and implementing strategies, monitoring their usefulness, and modifying them when appropriate. For example, after studying class notes several times in preparation for an exam, a student might ask a friend to be quizzed over the material. In this case, the monitoring component of the student's metamemory has indicated that he or she may be ready for a practice test. That is, the efficient executive knows when one knows and when one does not know, an important requirement for competent learning (e.g., Holt, 1964).

Brown took the perspective that memory monitoring plays a large role in these executive actions, and that metacognitive effects on cognitive regulation are more important than other metacognitive functions. In contrast to adults, children do not monitor well and often fail to make appropriate executive decisions. For example, children often fail to monitor comprehension problems when reading text (e.g., Baker & Brown, 1984; Garner, 1987). Brown (1978; Brown, Bransford, Ferrara, & Campione, 1983) made significant contributions to the development of metacognitive theory and mapped out some of the educational implications of metacognition by analyzing metacognitive process during comprehensive reading. Brown (1980) indicated that metacognitive abilities develop rather slowly during the school years.

Other researchers have also contributed to the development of metacognitive theory. Pressley and his colleagues (Pressley, Borkowski, & O'Sullivan, 1984, 1985; Pressley, Borkowski, & Schneider, 1987) elaborated the Good Strategy User Model, and later the Good Information Processor Model (Pressley 1995; Pressley, Goodchild, Fleet, Zajchwski, & Evans, 1989). According to the later model, metamemory is integrally related with the learner's strategy use, motivational orientation, general knowledge about the world, and automated use of efficient learning procedures. The contribution of these authors to the theory was the clarification of the linkage between knowledge about memory and the learner's efficient use of strategies.

Other contributions to the metacognitive theory were made by Wellman (1977, 1978, 1988) who focussed on the development of metacognition in early childhood. Five overlapping classes of knowledge were specified by him. These classes were based on Flavell and Wellman's (1977) model of metamemory knowledge that children develop during the school years. The most basic category is 'knowledge about existence,' including rudimentary knowledge of mental verbs such as 'thinking,' 'remembering,' and 'comprehending' and distinguishing mental processes such as remembering, knowing and guessing from external behaviors. The second basic category is 'knowledge of distinct mental processes' that develops rather late in the preschool years. Children of three to four years old are not capable of differentiating these processes. The third category is 'knowledge about integration,' that is the understanding of similarities between certain mental activities, such as thinking and remembering. The fourth category is 'knowledge about variables,' such as cognitive task and mental strategy. The ultimate is 'knowledge of cognitive monitoring,' that is awareness of one's own mental condition relative to task demands.

A variety of overlapping conceptions of metamemory were proposed by leading memory researchers. As a result of the complexity of metamemory processes, a variety of research approaches have been implemented to provide information about the many aspects of metamemory. In the following section a discussion of how metamemory is assessed will be presented.

3.2 Assessment of Metamemory

There are various measures that have been used to evaluate children's knowledge about memory. Most of these have utilized interviews or questionnaires that feature questions about memory processes. Cavanaugh and Perlmutter (1982) have introduced a distinction between two types of measures. One type are independent measures that tap pieces of information about memory that children possess, such as knowledge about memory capacities, strategies, tasks, and their interactions. The other type are concurrent measures that tap awareness of ongoing processing (i.e., measures of monitoring).

3.2.1 Assessing Memory Knowledge

With the exception of the Metamemory Battery Test that has been developed by Belmont and Borkowski (1988), almost all metamemory questionnaires have been administered to adolescents and adult subjects. The typical measures that are used with child subjects are verbal interviews. The best known verbal interview has been developed by Kreutzer et al. (1975). They interviewed children in kindergarten, first grade, third grade, and fifth grade about memory, using 14 items covering knowledge of person variables, task demands, and strategies. Most of the questions require the child to choose one option, other questions require verbal statements.

Much of the subsequent research in metamemory used portions of the Kreutzer et al. (1975) battery, with some attempts to assess the validity and reliability of items (e.g., Cavanaugh & Borkowski, 1980; Kurtz, Reid, Borkowski, & Cavanaugh, 1982; Schneider 1986; Schneider et al., 1986). Most of the data were consistent with Kreutzer et al.'s (1975) original findings (see below).

A number of other measures of metamemory have been used. Wellman (1977) developed a nonverbal technique to investigate metamemory of preschool children. Subjects were presented with pairs of pictures, each of which portrayed characters in a particular memory-related situation. The subject's task is to answer questions relevant to the pictures. For example, one picture shows a child trying to learn the names of 5 objects and another picture shows a child trying to learn the names of 15 objects. The questions to be answered are memory-related, such as questions about study time, age, or list length, or questions about irrelevant variables, such as the color of the hair. Wellman (1978) used rank ordering of pictured situations to evaluate children's knowledge about the interaction of memory variables (e.g., list length and study time). Yussen and Bird (1979) developed a similar procedure to test young children's knowledge about how variables like noise or study time affect memory performance.

Techniques to tap children's knowledge about strategies were developed by Justice (1985, 1986). Various memory strategies such as rehearsing, grouping, naming, and looking are presented to children on videotape. After the children watch a tape with a child using such strategies, they are asked to rank order the strategies on their efficiency in a free recall task. In subsequent studies this technique has produced consistent data (Schneider, 1986).

Best and Ornstein (1986) developed a method of assessment by teaching a memory strategy to a child who is then asked to teach a strategy to another child. The tutor's assignment is to describe to the younger children what they themselves would do when given a similar task. The tutor's instructions are taped and subjected to content analysis. The measure of metamemory is the extent to which the tutor's instructions include appropriate strategies (e.g., appropriate use of a suitable strategy, such as organization, in a sort-recall task).

The conclusion that can be drawn is that these measures of metamemory are highly dependent on self-reports and interviews. Meanwhile there is a history of skepticism about the validity of such measures. Therefore, metamemory researchers have developed other tools that can be used in convergence with these measures.

3.2.2 *Assessing Memory Monitoring*

Metamemory researchers have tried to redress the problems inherent in verbal self-reports through the use of concurrent measures. The number of such measures has increased substantially, largely because of interest in the area of reading (Baker & Brown, 1984; Garner, 1987; Pressley & Afflerbach, 1995). The most important feature characterizing concurrent measures is the presence of simultaneous memory activity (Cavanaugh & Perlmutter, 1982). In such measures, individuals are asked to perform a memory task and to report simultaneously or immediately afterwards their knowledge about how they performed the task and about factors that may have influenced their performance.

Concurrent measures have taken many forms. Performance prediction or memory estimation is most frequently used. In this form subjects have to predict or estimate how much will be learned prior to the study of to-be-remembered material. For example, predicting one's own memory span for various materials has been used often in developmental research (Flavell, Friedrichs, & Hoyt, 1970). Subjects are presented with lists of to-be-learned material, such as digits, words, syllables, or pictures. The task is to indicate how many items they can remember from the list; next the subjects actually perform the task, and the child's memory span is then taped. The metamemory index is the difference between the predicted value and the actual recall. Proficient memory monitors are more aware of their memory activity than children who have failed to monitor well. Prediction of performance accuracy has been measured for a variety of memory tasks. Recent applications of text material, for example, can be found in Schneider, Körkel, and Weinert (1990) and in Schneider and Uhl (1990, quoted in Schneider & Pressley, 1997).

In contrast to performance prediction, recall readiness assessments are made after material has been studied at least one time. In one variation subjects are asked to continue studying until they feel their memory of to-be-remembered material is perfect. Flavell et al. (1970) found that 5- to 6-year-old children are often unrealistic about their readiness for a test, low levels of recall occurring after they claim that they are ready for a test. More accurate assessments were obtained from older children.

Still another technique that has been used in a number of developmental studies exploring children's metamemory is 'judgments of feeling of knowing' (Brown & Lawton, 1977; Butterfield, Nelson, & Peck, 1988; Cultice, Somerville, & Wellman, 1983). Children are given a series of items and asked to name them. When a child cannot recall an item given its picture, he or she is asked to indicate whether the name will be recognized if the experimenter provides it. These feeling-of-knowing ratings are then related to subsequent performance on a recognition test that includes non-recalled items. Like performance prediction or memory estimates, feeling-of-knowing judgments are taken before the test. These concurrent measures have also been used with modifications that involve judgment of memory performance immediately after attempting a task, and making estimations on an item-by-item basis (e.g., Bisanz, Vesonder, & Voss, 1978; Masur, McIntyre, & Flavell, 1973).

3.3 Children's Factual Knowledge About Memory

Research on metamemory in the last two decades has produced a great deal of data, much of which is highly informative about children's knowledge about memory. Brief coverage of these findings is presented.

Understanding mental verbs such as knowing, thinking, remembering, and forgetting is considered basic knowledge of metamemory in children. Kreutzer et al. (1975) provided evidence that even the youngest children (kindergarten children) could properly apply these verbs. Wellman and Johnson (1979, quoted in Schneider & Pressley, 1997), conducted research on remembering and forgetting by asking preschoolers to judge the 'mental status' of an individual who either watched an object being hidden or who was blindfolded as the object was hidden. The individual then searched for the object, sometimes not finding it and sometimes finding it. The individual should be described as forgetting, if he possessed the necessary prior knowledge but did not find the object. If the prior knowledge was available and the performance was correct then the individual is considered as remembering or knowing. Guessing is the appropriate description when there was no prior knowledge available, and the object was located. Correct actions (locating the object) were described as remembering by Wellman and Johnson's subjects; incorrect actions were described as forgetting. Four-year-olds use mental verbs correctly and understand verbs like 'remember' and 'forget' much better than three-year-olds. Lyon and Flavell (1993) found that four-year-old children understand that retention interval is a critical determinant of forgetting.

3.3.1 Knowledge of Person Variables

Knowledge about person variables includes all permanent personality attributes that can influence the memory of information. In fact, there is not much research on knowledge about person characteristics that determine memory. Preschoolers appear to have a very limited understanding of how their own memory system works. Most young children do not recognize the limits of their memory capacities. Kreutzer et al. (1975) included only one item that tapped knowledge or awareness of person variables. It was found that 9- and 11-year-olds could conceptualize memory abilities in that they realized that memorization skills vary from person to person and from situation to situation. Children at this age also knew that they did not have an equally good memory in all situations and that it was quite possible for their friends to have a better memory than they did. In contrast, most of the kindergarten and first grade subjects thought that they always remembered well, and that they were better at remembering than their friends. In the Kreutzer et al. (1975) study, the self-concept of young children in memory tasks was unrealistic, almost 30% of the kindergarten were convinced that they never forget anything. Five and six year-old generally tend to overestimate their performance on memory tasks (Schneider et al., 1986).

Wellman (1977) used four questions that provided information about person-related metamemory possessed by preschool children. Three of these questions were related to irrelevant characteristics such as hair color, clothing, or weight, whereas the fourth question was directed to 'age' as a memory-relevant personal characteristic. More than 75% of the three and four year-olds and all of the five year-olds considered two of the three irrelevant factors as not important as determinants of memory. In contrast, only about half of the children in the sample recognized that memory improves with increasing age. Preliminary results from the Munich longitudinal study on the development of individual competencies that have been quoted in Schneider and Pressley (1997) indicate that four-year-old children do not know that there is a positive correlation between age and memory performance. Only 33% of the children of that age made a correct judgment about the relationship between age and memory. Nearly half of the 4-year-old children in the sample indicated that memory performance is related to the color of the hair.

It can be concluded that preschool children have great difficulty in determining the importance of relatively stable person characteristics that may influence memory. Young children's knowledge about the effects of age on memory performance becomes evident only when age is a salient item in a metamemory assessment questionnaire.

3.3.2 Knowledge of Task Variables

Knowledge of task variables that affect memory has also been evaluated. Wellman

(1977) provided the first hints that knowledge of task characteristics is available at preschool level. He included items related to a variety of task factors that can affect memory, such as list length (e.g., how much material there is to learn), circumstances of learning situations (e.g., noise and length of study time), and external support (e.g., help from parents or retrieval cues). Results supporting the competency of preschool children were obtained for variables relating to number of items and to 'noise.' Eighty two percent of the children were convinced that eighteen items are more difficult to remember than three items; 66% of the subjects said that 'noise' might negatively influence memory performance. Only 26% saw that the amount of time allocated for learning would have an effect on memory performance. Results of later research, for example, the Munich longitudinal study and Yussen and Bird's (1979) results, suggested that Wellman's (1977) findings have overestimated preschoolers' knowledge of task variables.

Yassen and Bird (1979) found that only 40% of the 4-year-old subjects could judge correctly the effect of the number of items on memory recall. Six-year-old children's knowledge of task characteristics is much more accurate than the knowledge of preschoolers. Seventy eight percent of six-year-old subjects understood that the number of items on a list affect memory performance. Almost all first grade children knew that noise negatively affects memory performance. About half of the six-year-old children in the study answered correctly the most difficult questions in terms of their relevance to memory performance, namely those pertaining to learning time.

Children's knowledge of the effects of other task characteristics on memory performance have also been explored. Moynahan (1978) asked children of seven, nine, and ten year olds to judge which of two lists would be easier to learn, one composed of taxonomically organized items or one composed of conceptually unrelated words. Although both older groups recognized the advantages of taxonomic structure, this did not hold true for seven year-old children. This result has been confirmed by Schneider (1986) in a follow-up study. He presented second- and fourth-grade children with clusterable lists that differed in the degree of interitem associations and category relatedness. He found that second-graders were more likely to cluster highly associated items than low-associated items.

In the study of Kreutzer et al. (1975) 55% and 65% of the children in kindergarten and first grade, respectively, knew that gist recall was easier than verbatim recall, while 100% of grade five children understood that verbatim recall was more difficult to retrieve. Another task variable explored by Kreutzer et al. (1975) was understanding how familiarity or prior learning of material can facilitate recall performance. Whereas children in kindergarten and fifth-graders alike were able to anticipate that relearning a list would be easier than learning it for the first time, older children were better able to explain why. In an early study Moynahan (1973) found that when learning categorized and non-categorized picture lists, third- and fifth-graders were better able than first graders to explain that recall is easier for related items. These findings were further extended by Yussen, Levin, Berman, and Palm (1979) who had children predict recall for three types of lists: lists with semantic categories, lists with physical (shape) categories, and random lists. In this study, first,- third,- and fifth-graders all recognized that semantically organized list would be easier to remember than random lists, but only the fifth-graders rated semantic organization as more helpful than physical organization. In comparing recognition tasks with free recall tasks, Speer and Flavell (1979) found that the majority of first-grade children did not know that recognition memory tasks are easier. Kreutzer et al. (1975) showed children two lists of word pairs, one list composed of pairs of opposites (e.g., hard-easy) and the other of random pairs (e.g., small-wash). Whereas third-and fifth-graders accurately noted that opposite pairs would be easier to learn, five- and six-year-olds did not show this awareness.

However, it has been suggested in a number of studies (Borkowski, Peck, Reid, & Kurtz, 1983; Kurtz, & Borkowski, 1987), that Kreutzer et al. (1975) may have overestimated kindergarten and first-grade children's knowledge of the relative ease of gist and verbatim recall. Also the robustness of the results of the organized lists either could mean that young children do not recognize that items in categorized lists fall into related groups, or that they do not realize that categorical organization may enhance recall. These results should not obscure the fact that young children do possess some accurate information about how task variables influence memory processes. Results have indicated that the majority of preschool children know that memory tasks are easier when retrieval cues are available, while more sophisticated understanding of retrieval cues and how they work develops during the primary school years (Schneider & Sodian, 1989).

One of the most common types of to-be-processed and to-be-remembered material in the real world is text. Children's knowledge of text structure was examined by Brown and her colleagues. Brown and Smiley (1977) asked students to rate pieces of information in a text as most important, slightly less important, less important still, and least important. The rating of third- and fourth-grade children differed greatly from that of adults, whereas grade-seven children provided ratings that were roughly similar to the ratings provided by college students. The apparently late development of text knowledge may be due to the fact that the text was fairly long and the rating procedures were rather complicated. When short and less complicated texts were used as well as less complicated rating procedures, the results indicated that elementary-school children do show knowledge of text structure (Kintsch & Van Dijk, 1978; Stein & Glenn, 1979). Later studies have suggested, that children are more proficient at differentiating important from less important material when reading text based on contents about which they possess expertise. A study with young children about the relative importance of text elements was reported by Young and Schumacher (1983). They showed that even their four- and six-year-old children were sensitive to relative importance levels within simple picture stories. Yussen, Mathews, Buss, and Kane (1980) showed that fifth graders could differentiate central from less central information in text, while second-grade children could not.

3.3.3 Knowledge of Strategy Variables

Kreutzer et al. (1975) asked children how they could help another child remember which Christmas he got his dog. Whereas most kindergartners could not arrive at any possible solutions, all of the fifth-graders offered viable strategies. These included taking trips through the mind in an effort to relive each Christmas or trying to remember other things about the dog that might spark some memories.

Kreutzer et al. (1975) included in their interview one item to assess knowledge of strategies that could be used in preparation of future retrieval. Subjects were asked to tell everything they could do in order to be sure to remember to take their ice skates to school the next day. The answers could be placed into four main categories, three external and one internal. The three external categories involved manipulation of the skates by (e.g., putting them next to the door), use of external memory cues, such as notes and relying on cues provided by other people (e.g., asking a parent to provide a reminder). The fourth category of answers involved internal processes that the child could carry out (e.g., rehearsal of the fact that the skates need to be taken to school). There was a significant developmental increase in the number of strategies reported. Even kindergarten children were able to come up with at least one strategy. All age groups reported more external than internal strategies. The strategies reported by grade three and grade five children were more efficient and clear compared with kindergarten and first grade subjects. A replication of this study (Borkowski, Ryan, Kurtz, & Reid, 1983; Cavanaugh & Borkowski, 1980; Kurtz & Borkowski, 1987) obtained similar results with respect to the question of the 'skates.' In the Munich longitudinal study (quoted in Schneider & Pressley, 1997) four-year-olds were asked a similar strategy question (What could you do in order to remember to take your snack box to school the next day?). Children in this age group reported only external strategies, 14% of the children suggested a manipulation of the snack box (e.g., put it at the door), 3% said that they seek help from others, 3% suggested using external cues such as making a note.

Kreutzer et al. (1975) assessed knowledge of retrieval strategies by asking what one would do in order to find a jacket that had been lost in the school. The answers were classified in two main categories, 'search' (referring to search procedures carried out by the child), and 'other' (referring to solutions that involved other people). Subjects at all age levels involved in the study suggested looking at places where the jacket was likely to be found (e.g., the cloakroom) and asking persons who would be likely helpful (e.g., the teacher). Suggestions to search systematically and elaborately were offered more often by fifth-grade children. First grade children gave on average two solutions. Generally every kindergarten child offered at least one strategy. In the Munich longitudinal study (quoted in Schneider & Pressley, 1997) only 25% of the 4-year-olds generated retrieval strategies.

In Kreutzer et al.'s (1975) study, questions were included that required subjects to make preparations to remember an upcoming event (i.e., the birthday party of a friend). This produced data that were similar to the data generated by the ice skates problem.

Increasingly sophisticated strategies were reported by older children, whereas most young children came up with one or two strategies. Retrieving information about an event that had already happened (i.e., remembering the Christmas when a particular gifts were received) was extremely difficult. Kindergarten subjects were not able to understand the task. First- and third-grade children said that they would seek assistance from other people, whereas older children (grade five) produced more varied strategies. These results have been confirmed by other researchers (Cavanaugh & Borkowski, 1980; Kurtz & Borkowski, 1984), who indicate that very few adequate responses were generated for the memory-of-Christmas item, and that knowledge of retrieval strategies starts to develop from four years of age through the grade-school years.

Knowledge about strategies that are useful for free recall tasks such as organization of to-be-remembered material were also tapped by a single item in the Kreutzer et al. (1975) study. The subjects were shown nine colored picture cards and they were told to imagine that these items had to be learned in order to be remembered in a few minutes. They were also told that they could do anything they wanted to acquire the items. The pictures were drawn from three distinct categories. There was a clear age difference in implementing organization strategies. When partial usage of a category was scored, 35% of the kindergarten children, 40% of the first grade subjects, 70% of the third grade subjects, and 80% of the fifth grade subjects evidenced at least rudimentary knowledge of organizational strategies. Only one kindergarten child out of the group of twenty children used a complete categorization strategy, while this was the case for thirteen out of the twenty subjects in the fifth grade.

Sodian et al. (1986) provided data on knowledge of organization strategies by presenting lists with items that could be categorized taxonomically or by color. Four and six year-olds were asked to make pairwise comparisons between taxonomic sorting, color sorting, random sorting, and looking strategies. The judgments of four and six-year-olds differed little, with only one significant difference between the two age groups. The 6-year-olds still did not realize the difference between taxonomic sorting strategy and the color-sorting approach.

Justice (1985) tested preschoolers on knowledge of the effectiveness of looking, naming rehearsal, and grouping strategies. He found that preschoolers considered 'looking at' as the best strategy. O'Sullivan (1993) confirmed that preschoolers consistently believe that 'looking at' is a good strategy, even though it is ineffective in improving recall. In general preschoolers and kindergarten children were more likely to view all four strategies as equally effective. Grade-six children have the understanding that semantic grouping strategies are superior to looking, naming, and rehearsal. Second and fourth graders preferred grouping and rehearsal, but did not differentiate between them.

Strategic behavior on memory tasks becomes more mature as children develops. Although this conclusion is well documented on a variety of tasks, the reason for the changes is less clear. Evidence supports the role of metacognitive knowledge (e.g., O'Sullivan & Pressley, 1984). Those investigators suggested that embellishing strategy instruction by adding information about metamemory in a trained strategy would increase children's generalized use of the trained procedure. Most of the research conducted on the relationship between metamemory and memory strategies has been in the form of training studies. In a simple design, memory and metamemory are assessed; then children are instructed in the use of one or more memory strategies, and finally they perform a post-test assessment of memory performance and strategy use. Investigators have also used 'transfer' tasks that assess the child's use of the instructed strategy in a task or setting that differs from the instructional setting. An assumption guiding much of this work has been that children who possess richer metamemory knowledge would be more competent than their peers at learning new strategies and at transferring them to other tasks. Strategy training studies have differed in whether or not metacognitive information about strategies was included as part of the instruction. According to Pressley, Forrest-Pressley, Elliott-Faust, and Miller (1985), most strategy instruction studies prior to the 1980s did not include more than minimal information about how to execute the strategy. Later investigations more often gave the learners specific information identifying those situations for which the strategy was especially suited, describing ways of modification to fit other tasks. One of the studies in strategy training that incorporated metamemory information was conducted by Paris, Newman, and McVey (1982). In this study, 7- and 8-year-olds were shown pictures on five consecutive days and were assessed on recall. On the first two days, the children simply practiced with the materials. On the third day, the children were given information about sorting pictures into similar groups, labeling the groups, using cumulative rehearsal, and performing self-testing. Half of the subjects were also told why the strategies were effective. In days four and five, strategy maintenance was assessed. Results indicated that the children who had been given a rationale for strategy use recalled more words, studied more strategically, and displayed more metamemory knowledge of strategies than the children who did not have the rationale.

Other studies assessed subject's general metacognitive knowledge prior to the study by administering a metamemory battery. For example, Kurtz and Borkowski (1984) provided children with information about the value of strategies. First and third grade children were assigned to three groups: One group received strategy instruction appropriate to each of three memory tasks, a second group received general metacognitive instructions, and the third received both strategy and metacognitive instructions. Later on maintenance and generalization versions of the memory tasks were given. Results indicated that the pretest metamemory scores were significantly correlated with strategy use on the generalization task, and that subjects who were initially high on metamemory skills profited more from the training instructions.

3.3.4 Knowledge of Interaction of Memory Variables

Knowledge about the interaction of memory variables (person, task, and strategies) was assessed by Wellman (1978). He presented memory problems to five- and ten-year-old children. Each problem consisted of ranking three picture cards, each of which contained a scenario to memorize. One set consisted of pictures of three boys, each of whom was supposed to remember some items, either 3, 9, or 18 items. This was a simple problem tapping a simple task variable (i.e., number of items). A more complicated interaction problem (item per strategy interaction) was depicted with the following three cards: (a) boy A was to remember 18 items merely by looking at them; (b) boy B was just to look at three items; (c) boy C was to write down the names of three items. This metamemory question was considered to be answered correctly if a subject indicated that boy A was likely to do less well than boy B, who was less likely to do well compared to C. Neither 5- nor 10-year-olds had any trouble solving the simple memory problems. There were, however, substantial developmental differences for the complex memory problems. The 10-year-old children performed almost perfectly, while the 5-year-olds only answered 32% of the complex memory problems correctly. The younger children tended to estimate task difficulty by taking only one of the two relevant features into account. Nevertheless, the conclusion can be drawn that 5-year-old children possess elementary knowledge of the combined influence of two variables. At the same time, interactive memory knowledge develops slowly and it appears that this development continues into adolescence (Schneider & Pressley, 1989; Wellman, Collins, & Glieberman, 1981).

3.4 Development of Memory Monitoring

Memory monitoring is the process of keeping track of one's progress towards goals concerning understanding and remembering. Monitoring may take the form of initial strategy selection, evaluation of strategy efficacy, or estimation of how much has been learned. Most of the research investigating memory monitoring either examines children's prediction of their memory performance, or children's allocation of effort in memory tasks.

Young children have difficulty estimating their memory abilities; in particular preschool children usually overestimate the amount of material they are capable of remembering. As mentioned before, Flavell et al. showed (1970) preschoolers and children in kindergarten, second-, and fourth-grade increasingly longer sets of pictures of objects and asked them if they could remember the order of the sequences. This procedure continued until the child indicated that he could not recall the long sequence correctly. When comparing each child's actual memory span using the same method, results demonstrated that most of the younger children (preschoolers and kindergartners) believed they could recall a sequence of ten pictures. In contrast, only 25% of the older children (second and fourth graders) predicted they could remember a ten-item sequence. Although both groups overestimated their memory abilities, the gap between actual and predicted span for the older children was smaller than for the younger children.

The problem with younger children not being able to predict or monitor their own memory accurately has been addressed by Schneider (1985). He presented two hypotheses. First, the tasks used in these prediction studies may not be familiar to young children, and thus they have difficulty accurately predicting their performance level in these novel situations. For example, if you were asked how many 'Arabic symbols' you could recall in the correct order, you may not be able to predict your memory span accurately due to lack of experience. According to this hypothesis, predictions would be expected to be more similar across age groups for tasks that are relatively abstract for both younger and older children. The other hypothesis offered by Schneider proposes that young children are unable to correctly estimate their memory span capacities, because they rarely think about their own memories. Schneider points out that the evidence in support of this hypothesis is mixed at best. Nevertheless, older children do appear to understand the limits of their memories better and are better judges of their memory span than younger children. Thus, knowledge of how best to monitor one's own memory appears to develop with increasing age.

The first hypothesis was addressed by Schneider (1986) and Schneider et al. (1986). Subjects made a prediction before attempting a list-learning task. After completing the task and a test, the subjects were told that they would be doing another list learning task and were asked to predict performance on this second list. Although the first and the second prediction did not differ in accuracy for second- and third-grade children, fourth-grade children's predictions did improve with practice. Pressley and Ghatala (1989) provided similar results. In their study, first-and-second graders, fourth-and-fifth graders, and seventh-and-eighth graders predicted performance on a vocabulary test, took the test, and then predicted performance on a future test of comparable difficulty. The results indicated that there was no evidence of prediction improvement from the first to the second prediction at the first-and-second grade level, while there was a strong trend toward improvement at the fourth- and-fifth grade level. A very clear improvement from first to second prediction also occurred at grade-seven and eight level.

When Schneider and Uhl's (1990, quoted in Schneider & Pressley, 1997) subjects went twice through the cycle of prediction-learning-testing with prose materials, there were no improvement in prediction with practice. Schneider and Uhl's interpretation is that an accurate estimate of the amount that can be recalled of prose text may be more difficult than an estimate for list items. Thus, monitoring during prose study and testing may not be sufficient to permit improvement in predictions about future prose learning.

Developmental shifts in the accuracy of individual-item predictions have been reported by Worden and Sladewski-Awig (1982). They demonstrated that second-grade children were more liberal than sixth-grade children in their predictions. Thus, the younger children were more likely than the older children to predict memory of items that in fact were not remembered subsequently.

Another area of research investigating age differences in memory monitoring centers on the amount of effort and attention children allocate to memorization. Brown and Smiley (1977, 1978; cf. also Brown, Smiley, and Lawton, 1978) studied children's attention on a reading task with the goal of remembering the text on later recall. Because both comprehension and learning are required in order to successfully remember what has been read, the successful learner monitors performance while reading. For example, if a paragraph is confusing or difficult to understand, the reader will slow down and might re-read. The development of this complex skill requires much experience with various types of text. Brown and Smiley also tested the hypothesis that older students would use these skills and additional time to increase their knowledge and understanding of the themes of a text. They expected that older students, compared to younger students, would realize that more attention should be given to critical story themes and thus would spend more time and effort on such passages. Results indicated that while fifth-graders' knowledge of story themes did not increase with extra study time, seventh-graders and older students dramatically increased their understanding of story themes when more time was provided. In addition, the younger children were more likely to include extraneous, unimportant ideas in their recall protocols than were older children, whose recall generally focused on phrases that the authors had established as more important.

Knowledge of recall readiness can be assessed after material has been studied at least once. In the study by Flavell et al. (1970) kindergarten and first-grade children were unable to recall a learned list correctly, although they believed that they would be able to do so. Recall readiness estimates of second- and fourth-grade subjects were considerably more accurate. Flavell et al. argued that the older children's accurate assessment was due to their greater use of self-testing during study.

Knowledge of time allocation as related to recall readiness was studied by Masur et al. (1973). They asked subjects of first grade, third grade, and college students to learn a list of pictures and then to answer a free-recall test. After the first study and first recall trial, subjects were asked to select half the pictures for additional study. Third grade and college students tended to select items not recalled correctly on the first trial, but first grade subjects did not consider recall experience in making a selection of items for additional learning. Similar findings were obtained by Bisanz et al. (1978) in a paired- associate task. Fifth grade and college students were more likely than first grade or third grade students to select items not learned on a first trial.

Thus, young children do not allocate more study time to items that they have not yet mastered, maybe because they are unaware which materials are not known. They know which parts of text are easier to acquire than others (Danner, 1976; Pressley, Levin, Ghatala, & Ahmed, 1987; Pressley & Ghatala, 1989), but knowing which information is easier to learn and which is difficult is not sufficient to result in appropriate monitoring or self-regulation by spontaneously studying the items that have yet to be learned.

Spontaneous allocation of study time in first-, third-, fifth- and seventh-grade children was assessed by Dufresne and Kobasigawa (1989). Subjects were asked to study text consisting of either easy (highly related) and difficult (unrelated) paired-associate items until they were able to remember all pairs perfectly. Children in first- and third-grades spent about the same amount of time on easy and hard pairs, whereas the fifth- and seventh-grade children devoted more time to studying difficult items. These results confirm studies that memory monitoring can be observed in older children but not in younger school age groups. Dufresne and Kobasigawa noted that their younger subjects were able to differentiate between easy and difficult item pairs, but that their monitoring knowledge was not transferred into adequate allocation of study time.

Finally, several researchers have provided evidence that memory monitoring training guides the effectiveness and maintenance of strategy use. For example, Ringel and Springer (1980) trained first, third, and fifth graders in using an organizational strategy. At the baseline phase, all the subjects demonstrated increase in memory performance as a result of training. After completion of the training, a memory task designed to assess transfer of training was administered. Fifth graders demonstrated successful transfer of the organizational strategy, whereas first graders failed to demonstrate any significant transfer. Some but not all third graders transferred the organizational strategy. The older children were capable of transferring the organizational strategy, presumably because they were efficient in assessing their own progress, while the younger children were either incapable of transferring the strategy or insufficiently trained.

3.5 Relationships between Metamemory and Memory

Research into the relationship between metamemory and memory has examined both theoretical and empirical perspectives. Despite the diversity of research approaches, most studies have produced only low or moderate correlations. For example, Kelly, Scholnick, Travers, and Johnson (1976) reported only a tenuous relationship between memory monitoring and strategic behavior in eight- and nine-year-old children. In an experiment to determine the nature and strength of metamemory-memory connection, Cavanaugh and Borkowski (1980) had subjects from first, third, and fifth grades participating in two sessions. Metamemory was assessed during the first session by an extensive interview. Memory strategies and performance were independently measured during the second session with three tasks: free sorting, cognitive cueing and alphabet search. They reported age-related increases in both metamemory knowledge and memory performance, but within each group the two factors were only weakly related.

Most investigations of the relationship between metamemory and memory have been correlational. Subjects are evaluated on some aspect of memory knowledge, asked to perform a related memory task, and then correlations between measures of metamemory and memory performance are computed. Studies based on this approach (e.g., Cavanaugh & Borkowski, 1979, 1980; Kendall, Borkowski, & Cavanaugh, 1980; Perlmutter, 1978; Ringel & Springer, 1980; Yussen et al., 1979) have yielded only moderate or low correlations between metamemory and memory.

Given the hypothesized relationship between metamemory and memory, the failure to uncover substantial metamemory-memory correlations is perplexing. A number of potential reasons are suggested to explain such results. It is probable that metamemory-memory connections are complex and are likely to involve multiple aspects of knowledge about memory (Flavell & Wellman 1977). There are also procedural reasons for the lack of strong correlations in these studies.

Previous research has demonstrated that the strength of memory-metamemory relations varies with both the nature of the memory task and with age. Wimmer and Tornquist (1980) had subjects from three age levels (7, 10, and 17 years) serving in an awareness and in a control condition. In the awareness condition knowledge about the effect of categorical grouping on recall (metamemory) was questioned before the main memory task, while in the control condition the metamemory question was subsequent to the main memory task. Categorical grouping as a preparation for recall (mnemonic performance) was assessed by using both a liberal criterion (assessment of categorical grouping when subjects used eight or more category repetitions out of a total of 27) and a conservative criterion (when subjects picked two instances of a category and placed them together). There were developmental differences in metamemory, half of the seven year old subjects knew the effect of categorical grouping on recall, while 60% of the ten year-olds and nearly all of the seventeen year-olds had this knowledge. The results also produced a clear correlation between knowledge of organizational strategies and their use in all three samples.

When simple tasks are used and metamemory questions that are highly related to successful task performance, the correlations between metamemory knowledge and memory behavior are significant, even for young school children. For example, Schneider and Sodian (1989) used a retrieval cue task by asking four and six year olds to remember ten objects that they placed in each of ten playhouses. Each playhouse was associated with pictures of people who could be identified by their professions (for example, a farmer, a sailor, a soccer player). Some of the objects could be associated with the people (a tractor, a ship, a soccer ball), whereas others could not (for example, a letter, a flower, a book). Both age groups recognized the importance of pairing the objects with the people and performed well on the memory test. Thus, the relation between metamemory and memory is significant for four-year-olds when tasks are simplified and metamemory questions are directly related to the memory behavior.

Schneider (1985) carried out a meta-analysis of studies containing metamemory-memory relationship data. He averaged the available correlation coefficients from the individual studies, reporting an overall correlation of .41. This meta-analysis was based on 27 publications, which generated 47 correlations. Because most studies reported correlations aggregated over age, there are few correlations for separate age levels. The correlations for memory monitoring were larger than the correlations for organizational strategies among younger children. This meta-analysis provided a good sense of the overall quantitative relationship in the data, where the significant values of metamemory-performance correlations can be taken as a sign of the role of metamemory in directing memory processing.

In several studies (e.g., Kurtz, Schneider, Turner, & Carr 1986, quoted in Schneider & Pressley 1997; Schneider, 1986; Schneider et al., 1986) multivariate regression analyses have been used to determine the relative importance of metamemory components and other potential predictors of semantic-organizational strategy use for memory performance in tasks that can be mediated by semantic categorization. From about the third grade, metamemory variables have emerged as significant predictors in these analyses (Kurtz et al., 1986; Schneider et al., 1986). Metamemory predicts recall even when other variables are held constant statistically; particularly task-specific metamemory is a better predictor than general metamemory measures (Borkowski, et al., 1983; Kurtz et al., 1982).

Lately more sophisticated approaches than regression have been used to detect the relationship between metamemory and memory behavior, including causal models. These models generally assume that metamemory precedes memory behaviors. Therefore, a child's knowledge about his memory ought to affect strategic behavior, and the amount of strategic behavior can be used as a basis for predicting memory performance. According to Schneider and Pressley (1997), models presented in the literature vary in the extent to which they operate on observed versus latent variables. Two versions of latent-variable models have been used: (a) Exploratory approaches that emphasize the construction of a potential model given the data at hand: (b) Confirmatory approaches that permit tests of hypothesized relationships specified in advance.

There is some evidence that metacognitive judgments about strategic use of categorical list structure directly affects categorical strategy use and amount recalled in a task presented a week later. Fabricius and Hagen (1984) illustrated this in a study using path analyses with observed variables. Path coefficients between metamemory and organization during recall, and between metamemory and recall, were positive, but they were not statistically significant. Also, the use of sorting strategy did not directly affect recall. Fabricius and Hagen (1984) limited their interpretation to the direct paths. However, as shown by Schneider and Pressley (1997), it is possible to calculate the indirect paths, based on the coefficients presented in their report. The indirect effect of metamemory on clustering during recall is then shown to be greater than the direct effect. The same was true of the indirect effect of metamemory on recall. Thus, the contribution of metamemory is more obvious when both direct and indirect effects of metamemory on subsequent memory behavior and performances are considered.

Studies that used causal models with latent variables (Borkowski et al., 1983; Kurtz et al., 1982; Schneider, Körkel, & Weinert, 1987; Weinert, Scheider & Knopf, 1988), tend to provide more evidence of relationships between metamemory, strategic behaviors and memory performance than studies not using such models. These analyses permit the conclusion that even young primary-school children possess metamemory knowledge that has a direct influence on strategic behavior, i.e., the tendency to organize to-be-learned material taxonomically.

Schlagmüller, Visé, Büttner, and Schneider (1995, quoted in Schneider & Pressley,

1997) provided evidence of relations among metamemory, strategic behavior and performance in sort-recall tasks. Data were obtained from samples of third- and fourth-grade children by administering a metamemory battery, a memory span test, articulation tasks and an intelligence test. A causal modeling analysis was applied. The results indicated that both IQ and memory capacity had a moderate effect on metamemory, which in turn had a strong direct impact on strategic behavior and a modest direct effect on recall. Metamemory had a substantial indirect impact on recall, which operated through strategic behavior. Thus, individual differences in metamemory explained a large proportion of the variance in the recall data.

3.6 Antecedents of Metamemory

Children's metacognitive knowledge begins with home experiences, it is initially guided by their parents. Pierce and Lange (1996) examined children in second and third grade on recall and metamemory knowledge in relation to the home environment. Parents answered a questionnaire that measured help and encouragement of their children to use planful and strategic behavior on homework and other memory activities. The results indicated that home experience predicts children's metamemory and strategy use on memory tasks; children encouraged by their parents to plan activities exhibited higher levels of knowledge about memory strategies and higher performance on item recall. Parents may do some teaching themselves and children may pick up a strategy on their own in some context, but memory strategies are primarily useful to children in school.

Strategy instruction in school has been examined fairly extensively in American schools (e.g., Moely, Santulli, & Obach, 1995). Teachers showed considerable variability in amount and type of strategy instructions, with some tailoring their instructions to make strategies age appropriate. Strategy instruction varied with subject matter, for example, strategies were more likely to be taught for solving math problems. Moely and her colleagues concluded that children from classrooms where strategies were taught more often, gained some advantages from their experience, showing higher levels of achievement.

Differences in strategy instruction in the home and in school may account for cross-cultural differences in memory performance. As discussed in Chapter 4, for example, research comparing German and American children on sets of strategic memory tasks reported a consistent advantage for German children as young as seven years of age (Carr, Kurtz, Schneider, Turner, & Borkowski, 1989; Kurtz, Schneider, Carr, Borkowski, & Rellinger, 1990; Schneider et al., 1986). The apparent reason for the German children's superior performance was found in instructional practices in their homes and schools. Questionnaires completed by children's parents and teachers revealed that the German parents engaged in more games requiring strategies with their children than did the American, and that the German teachers taught more strategies in schools than the American teachers.

Research on the development of memory strategies as an antecedent factor of metamemory has noted that there is substantial variability in the strategies children used, both between children of a given age (interchild variability) and within a single child over repeated trials on a task (intrachild variability). Rather than viewing the development of strategies as a progressing in a step-like fashion, Siegler (1995; Siegler & Jenkins, 1989) proposed a strategy-choice model in which children have available and use a variety of strategies. What changes in the course of development is the frequency with which these various strategies are used. Based on this framework some research has been conducted. For example, McGilly and Siegler (1989, 1990) asked kindergarten, second-grade and fourth-grade children to remember a list of digits in exact order over repeated trials (a serial-recall task). Consistent with the strategy-choice model, they found that children used a variety of different strategies and that any given child used a combination of strategies over repeated trials. Other research, examining performance on free-recall tasks, has found that children as young as four years of age use different combinations of strategies (e.g., rehearsal, sorting, and category naming) and that older children tend to use more sophisticated strategies than younger children (Lange & Pierce, 1992). Other researchers have reported that third-grade children who were instructed to organize words by meaning, not only improved their memory performance but also used more sophisticated rehearsal techniques (Cox, Ornstein, Naus, Maxfield, & Zimler, 1989). That is, improvement in one strategy (organization) is associated with improvement in another strategy (rehearsal), which in turn leads to enhanced memory performance. In fact, Siegler (1995) notes that strategies are not always selected in order to improve performance; sometimes children use a strategy because it is novel and this may lead to less than optimal performance.

One obvious antecedent factor of metamemory is motivation. Children can be motivated to use strategies. Extrinsic rewards on children's strategy use have been studied (Cuvo, 1974: Kunzinger & Witryol, 1984). For example, Kunzinger and Witryol (1984) gave seven- and eight-year-old children sets of words to rehearse and remember. Some words were identified as ten-cent words. Children would receive ten cents for every word they remembered. Other words were designated as one-cent words. The findings indicated that young children can be sensitive to differences in 'payoff' and modify their strategic behavior and recall according to extrinsic incentives. Other research has investigated the effects of rewards on study time. For example, O'Sullivan (1993) provided four-year-olds with either a highly valued toy (a box of crayons) or a less valued toy (a pencil) for good memory performance. She reported that children used more sophisticated strategies and paid more attention to the task when they were expecting the highly valued toy for reward. Guttentag (1995) reported similar results for third-grade children. However, in both of these experiments the highly incentive conditions did not result in higher level of recall, reflecting the motivation to choose the more valued strategy even though this did not produce better performance.

Intrinsic motivation has also been explored. For example, several theorists have proposed that children who attribute their success to the use of effortful strategies should be more motivated in spending effort for success than children who attribute success to factors such as task difficulty or luck. Fabricius and Hagen (1984) showed that such causal beliefs predicted strategy use better than verbalized statements about memory processes. Kurtz and Borkowski (1984) discovered that among strategy-trained children, those who attributed success to effort were higher in metamemory and more strategic on transfer tests than those who attributed task outcomes to uncontrollable factors. Schneider et al. (1986) have investigated the relationship between attribution beliefs (as measured by a success and failure questionnaire and preference for challenging tests) and strategy use in a sort-recall task for subjects in the fourth-grade. Correlations between measures did not exceed .30, but were mostly significant.

With respect to strategy use, there is one study that has emphasized the importance of interest in strategy instruction (Pressley, Wood, Woloshyn, Martin, King, & Menke, 1992). Children are more apt to spend time on tasks that they are interested in , which may result in higher memory performance on these tasks.

Individual differences in intelligence are a major antecedent factor of metamemory (e.g., Bjorklund & Schneider, 1996; Borkowski & Turner, 1990; Schneider & Weinert 1990). Borkowski and Peck (1986) contrasted gifted and average children at the age of seven and eight years on a variety of tasks assessing perceptual efficiency, strategy use, general knowledge, and metacognitive knowledge. Sizable between-group differences emerged on all tasks. In a subsequent follow-up study with the same children, Borkowski and Peck traced the emergence of strategic behavior with differing degrees of strategy training. The results confirmed the prediction that gifted children have an advantage over the normal children on most memory tasks. For example, gifted children were faster than normal children in accessing information from long-term memory. Gifted children were capable of storing and maintaining significantly more words than normal children in memory as evidenced by differences on the word-span tests. Substantial differences between the two groups were found on measures of metamemorial knowledge. Gifted children reported a greater number of strategies for retrieving information. Schlagmüller et al. (1995, quoted in Schneider & Pressley, 1997), using a causal modeling analysis, found that both IQ and memory capacity, measured in terms of memory span, as antecedent factors had a moderate effect on metamemory. Thus, the data are suggestive that intelligence is an antecedent factor for metamemory, for successful strategy training and for transfer to more general contexts. Gifted and high-IQ children have better metamemory knowledge on strategic memory tasks than non-gifted children have (cf. also Carr, Borkowski, & Maxwell, 1991).

Overall, the results of the studies described in this section present evidence for interactive relationships among antecedent factors in metamemory. Although some of factors may have a greater influence than others, it is not possible to point to any single factor as the principal cause of metacognitive knowledge and strategy use of school age children.

3.7 Summary

The research discussed in this chapter provides a clear indication of relationships between metamemory knowledge and memory performance. The nature of this relationship varies as a function of age and task characteristics. Generally, children's knowledge about strategies seems to improve performance in memory tasks.

In order to understand metamemory-memory performance relationships it is desirable to uncover quantitative associations between the various components. The complexity of metamemory-memory behavior relations makes it obvious that no single method or statistic can capture the diversity of the required analyses. Still, the combined evidence of numerous studies provides a general picture of non-trivial correlations between metamemory and memory. Moreover, some correlations are consistently greater than others; here tend to be stronger relationships between metamemory and strategy use than between metamemory and general memory. This suggests that successful strategy use and transfer are dependent upon the availability of metacognitive knowledge that individuals have acquired. Research with gifted children shows that they gain more than normal children do from metacognitive knowledge that helps to confront the challenge of new task demands and perhaps improves performance in all learning conditions.

Chapter 4

Cross-Cultural Research on Memory Development

4.1 Introduction

In recent years there has been an emerging trend in the memory literature towards examining environmental factors in early memory development (Perlmutter, 1988). There is increasing recognition that to understand memory performance, especially of individuals from different cultures, it is necessary to place memory activity in the context of a group's interpretation of the task to be accomplished. This was not well recognized prior to the 1970s when contextual factors and their influence on performance were ignored in much of the research on cognitive development (Butterworth, 1993; Cole et al., 1971). Cognitive skills were typically conceptualized as context-free competencies located within the individual. Thus, experimental paradigms using laboratory tasks were commonly used to study cognitive processes, such as memory, as 'pure' processes. For example, the influence of contextual factors, such as an individual's prior knowledge, was removed by studying memory for nonsense words.

Nevertheless, already in the early 1930s, Bartlett in his very informative book, had described memory as a contextual phenomenon, emphasizing that 'both the manner and the matter of recall are often predominantly determined by social influences' (Bartlett 1932, p. 244). He documented the prodigious retention capacity of Swazi herdsmen to recall the individual characteristics of their cattle and argued that this was not surprising since Swazi culture revolved around the possession and care of cattle. When the purpose for remembering did not have social or economic importance, Bartlett demonstrated that a Swazi herdsman who was able to remember details of all the cattle his owner had bought a year ago, could not recall any more words from a set than a typical Western youth could.

Based on a contextual approach, cross-cultural research in memory development has begun to focus on the interpretation of intergroup differences in memory performance. When memory tests are administered to groups of Western and non-Western subjects, the former group almost invariably obtains higher scores. However, the interpretation of cross-cultural differences in cognitive abilities, including memory performance, involves a serious dilemma. Are the results a valid indication of differences in memory functioning between cultural groups, or should they be explained in terms of bias or incomparability of the data? The most obvious example to illustrate the dilemma is the controversy on the measurement of intergroup differences in intelligence test scores. Two views have emerged, the egalitarian rationale maintains that unequal mean scores on tests reflect differences in concomitant variables, such as test taking attitudes and the prior opportunity to acquire information needed to perform well on the test. Non-egalitarian views hold that inferences about cross-cultural differences in intelligence are justified, arguing that such results reflect real differences in cognitive abilities that can be attributed to genetic intergroup differences.

This chapter begins with an overview of studies in recall and recognition memory among different cultural groups, to show the diversity and to demonstrate how individual remembering is supported or constrained by features of the activity in which remembering takes place. Many studies have focused on memory strategies that have been used by individuals who have had certain kinds of experiences. Cross-cultural research also was conducted to test the familiarity hypothesis or the issue of knowledge base, as it relates to memory performance. Studies on the role of metamemory are reviewed. Although it is an area of considerable practical use, there has been little cross-cultural work in this area. Finally, the contribution of cross-cultural research to the area of memory development is discussed.

4.2 Cross-Cultural Studies on Memory Strategies

The dominant trend in research on the development of children's memory has been to search for changes in underlying competencies that characterize universal development (Perlmutter, 1988). Age difference in use of verbal memory strategies, age-related increases in operative knowledge (i.e., knowing how to use mnemonic strategies), content knowledge, and metacognitive knowledge are assumed to contribute to age-related improvements in memory performance (Perlmutter, 1988; Schneider & Pressley, 1989).

Cross-cultural research on the effects of cultural factors on memory has been particularly useful in evaluating whether the changes in memory performance observed across childhood in the USA and other Western countries may be due to experience with school rather than maturation (Rogoff 1981; Sharp, Cole, & Lave, 1979). Merely documenting differences in performance as a function of schooling does not explain how and why these differences occur. We need to understand what processes mediate the generally better performance of schooled children.

Memory development has been studied in cross-cultural settings, with a focus on children's performance as a result of age, schooling, and environment. Because school is an institution where memory behaviors are expected and rewarded, it is extremely likely that schooling affects the development of memory strategies. It is impossible to decide on the basis of Western data alone whether strategy development is a function of maturation or schooling, because chronological age and amount of schooling are largely confounded in Western culture. The examination of such variables, necessarily requires cross-cultural experiments. The most frequent design used in comparative research of memory consists of measuring memory performance in Western and non-Western samples.

Cole et al. (1971) conducted a series of studies with Kpelle subjects in Liberia to investigate memory performance as related to schooling and culture. Clustering in memory output was investigated by using free recall tasks. This procedure allowed assessment of both recall and the amount of clustering during recall, which can be taken as one indicator of the use of organizational strategies. A list of clusterable or non-clusterable familiar words or objects were presented to the subject, who was asked to recall as many items as possible following the presentation of the last list item. Three age groups were involved: 6- to 8-year-olds, 10- to 14-year-olds, and 18- to 50-year-olds. The two younger groups included approximately equal numbers of schooled and unschooled subjects. None of the adults had attended school. A group of Californian children participated as a comparison group. The differences between the American and African samples in memory behavior were enormous. Adults and children in the Kpelle sample did not show a significantly different performance. African subjects did not improve much on repeated trials. It was apparent that the American 11-year-olds used categorical information to mediate recall. In contrast, low clustering was found in the Kpelle sample. The results suggested that semantic organization strategies and verbal rehearsal were not spontaneously employed by the Kpelle subjects.

Other studies of free recall have confirmed the effects of experiential factors such as education on memory performance. In a cross-cultural replication of Cole et al. (1971), Sharp et al. (1979) studied memory performance in an adult population in Yucatan, Mexico. The memory task was quite similar to that employed in the earlier Liberian studies. Twenty common nouns were selected forming four basic taxonomic categories. Each list was presented five times, and free recall was used to assess memory performance after presenting each list. Results showed that the effect of age was not significant, and that recall was much related to school attendance. Furthermore, extensive use of clustering to aid recall was observed only in educated subjects. When regression analysis was performed, sociodemographic variables (age, sex, parental occupation, and language) were of little predictive utility beyond the variable of years of schooling.

Investigating the effect of schooling on organizational strategy, Pollnac and Jahn (1976) replicated studies of taxonomic clustering behavior with school children at the age of 13 to 15 years in Uganda. The subjects were selected from three different schools (two were public; one was religious and required children to recite long prayers). Lists of clusterable words were constructed, each list was read twice to the subjects, after which recall was required. The most unusual outcome was that both clustering and higher recall were exhibited by the students in the religious school, whereas little clustering was evidenced in the other schools. Pollnac and Jahn pointed out that the religious school may have provided the necessary skills for the pupils to increase recall. The results of the study also provided support for the hypothesis that the activities children practiced in the school are more important than schooling by itself.

To investigate the notion that school practices organize ways that help individuals remember, Scribner and Cole (1981) designed a memory task resembling the incremental method of learning the Quran, practiced by literate Arabs (i.e., adding a new statement to a series at each attempt). They compared the performance of Vai people who varied in the use of three types of literacy: Arabic literacy gained in study of religious script in traditional Quranic schools, literacy in the indigenous Vai script learned through informal means for practical correspondence in trade, and literacy in English learned in Western-style schools. The Arabic literate had an advantage over the other groups on recall of words when preservation of word order was required, consistent with memory practices used in learning the Quran. However, on recall tests of words irrespective of order, or on recall of stories, the Arab literate did not perform better than the Vai literates did. Scribner and Cole (1981) concluded that learning to be literate in the Quran influences recall only when the format and sequencing of the to-be-remembered material models previous learning habits.

Kagan and Klein (1973) explored free recall among Guatemalan children, aged 5 to 12. The subjects were chosen from two contrasting populations. One group was neither schooled nor had any contact with written language; the other group was more modern and had a school education. The materials consisted of 12 miniature objects from three conceptual categories. After a brief presentation, the objects were covered with a cloth. In a free recall task the children had to remember as many objects as they could over two trials. Recall varied from five to ten items, and increased with age. Also, clustering was evident for almost all children. Kagan and Klein claim that these recall results compare favorably with data collected from American children by Appel, Cooper, MacCarrell, Sims-Knight, Yussen, & Flavell (1972). However, such a comparison would seem unwarranted, because modality, number of stimuli, and number of conceptual categories varied across the two studies; all such factors are known to have possible effects on recall.

It has been found in laboratory studies that concrete nouns are better recalled than abstract words. Parker (1977) suggested that there is anecdotal evidence on the concreteness of African thought having effects on remembering concrete objects better than abstract nouns. Parker (1977) tested this hypothesis by comparing college students in Ghana and United States on a memory task of remembering concrete and abstract word lists. The results indicated that there were no differences in words recalled by Ghanaian and American students. There were significant effects for concreteness of trials, but concrete versus abstract was not found to interact with culture. However, the American subjects showed more rote memorization behavior than the Ghanaian students and the analysis of serial position curves in the free recall output showed variation across cultures in respect of recency effects.

In a study undertaken in Mexico, Wagner (1974) examined the spontaneous employment of intentional memory strategies using a serial memory task. It was assumed that the analysis of serial position curves would enable conclusions about intentional rehearsal processes, in line with Atkinson and Shiffrin's (1968) distinction between structural and control processes. The subjects were presented with task materials that consisted of series of drawings of animals and objects familiar to the subjects. These were drawn on seven cards, which were presented as a serial memory task; each of the seven cards were first shown and then placed face down. The subject was shown a single 'probe' card with an animal, and had to find the location of the same animal in the linear array of face down cards. The task provides a serial position curve, in which there is a primacy effect that is a function of rehearsal, as well as a recency effect. The latter provides a measure of short-term store (considered to be a structural feature of memory). The results indicated that recall of recent items was stable and relatively invariant across all groups, regardless of age, schooling and environment. There were differences in primacy recall reflecting greater use of rehearsal associated with age and schooling.

Wagner (1974) concluded from these results that memory strategies for serial recall are only employed spontaneously by older subjects with schooling. Results from several studies using probed serial recall tasks support the idea that cultural differences reside more in the use of strategies than in structural aspects of memory (Rogoff & Mistry 1985).

In another line of cross-cultural research, Wagner (1978, 1981) has pointed to an important problem with this study, namely that the effects of schooling and cultural setting were confounded. The subjects with school experience came from the capital of the Yucatan province in Mexico, whereas the unschooled subjects were recruited from rural areas. Thus, the between-group differences could have been due not only to schooling, but also to environmental (urban-rural) differences. These two factors were separated in Wagner's (1978) work conducted in Morocco, where there is a wide variation in schooling and degree of urbanization. Two main experiments were carried out with Moroccan subjects, who were selected to represent variation in age (6- to 9-year-olds, 10- to 12-year-olds, 13- to 16-year-olds, and 17- to 22-year-olds), schooling (schooled versus unschooled) and environment (urban versus rural). Thus, it was possible to analyze the effect of age, schooling, and urbanization factors separately. The results confirmed the previous findings with the Yucatan subjects. Both schooling and urbanization had an effect on overall recall, with the urbanization effect especially apparent in the younger children. The effect of schooling was greater among the older subjects, starting at about 13 years of age, while the effect of environmental factors (urban versus rural) decreased in importance with increasing age. The number of years in school seemed to be important in producing the 'primacy effect.' Schooling increased overall recall and older schooled children also showed better primacy recall than unschooled subjects. This has been interpreted by Wagner as evidence that rehearsal strategies are a product of schooling.

Wagner and Spratt (1987) conducted a longitudinal study of literacy acquisition and remembering in Moroccan children in urban and rural areas. The children were in the first year of primary school. The main contrast in the study was to compare children who attended 1-2 years of Quranic schooling before entering primary school with those who attended little or no Quranic schooling; and children who had attended one to two years of modern (Western type) preschool. The major interest of the study was the specific effects of the (Quranic) rote learning on children's memory skill. The overall between-group differences favored the Quranic group relative to the non-Quranic groups. The memory capacities of Quranic school children differed from same-age Moroccan children receiving modern schooling in the superiority of serial learning. The Quranic pupils had developed strategies for doing the memory task demanded of them.

Further support for the effects of schooling on memory performance of children was also provided by Rogoff's (1981) findings, using multiple regression analyses, that memory performances on text remembering was better predicted by number of years in school than by age or social background variables.

All in all, cross-cultural findings on the effect of schooling on memory strategies can be understood as an instance of how a cultural institution (schooling) provides practice in performing memory tasks. Western schooling provides children with culturally based definitions of cleverness and acceptable means for solving problems (Rogoff & Mistry, 1985). It provides an emphasis on fast performance as in timed (speed) tests, which are unusual outside of school in many cultures. Western schooling may provide practice in specific approaches to memory problems, such as the imposition of organization on arbitrary items. The cultural tools and techniques generally used in school also involve conventions and formats which are useful in typical memory studies, such as organizing a list by taxonomy rather than on the basis of function.

Research discussed in this section so far has involved laboratory tasks. Research with text as stimulus material does not support the position that cultural background determines memory performance. On the contrary, universal schemata tend to emerge that are operative during the encoding and recall of stories so that almost no differences are observed as a function of culture or level of formal education. Mandler, Scribner, Cole, and DeForest (1980) presented Vai children and adults (either schooled or unschooled), with a total of five stories, one of which was of Vai origin, while the rest was Western in origin. Significant differences were found between children and adults with regard to total recall of the stories. More important, there were no differences in recall of familiar and unfamiliar types of stories (i.e., no superior performance on culture-specific types). A comparison of these results with those of earlier studies that were carried out with American school children and college students (Mandler & Johnson, 1977) produced evidence that the recall patterns of the stories (in terms of structural elements of the stories that were recalled) remained rather invariant in both cultures.

Mandler et al. (1980) concluded from these results that the general schematic structure of the stories is an important determinant of recall performance. The results supported the assumption that story schematic elements are important mediators of text learning and recall. The structural similarity of story recall in children and adults from different cultures suggested that certain general structural schemata have universal meaning. Dube (1982) provided more support for the Mandler et al.'s (1980) conclusions. He presented two stories of African and two of European origin to African and American high school students and to African adolescents without school experience. In general the African subjects demonstrated better memory performance than the American group. There were no differences in memory for the European and African stories. The African subjects' superiority of memory performance was interpreted by Dube (1982) as being due to their greater experience with oral story telling. In an earlier study, Ross and Millson (1970) obtained a similar results in a comparison of adults from Ghana and United states, where the Ghanaian subjects outperformed subjects from New York City.

Different results were obtained in a study on story recall by Rogoff and Waddell (1982) with nine-year-old Guatemalan Mayan and American children who were asked to recall stories that were adopted from the Mayan oral literature. Extensive efforts were made to make the task culturally appropriate for the Mayan children. The stories were told to the children by a familiar teenager speaking the local Mayan dialect, in a room that the children had become familiar with through several play sessions and parties. In an effort to make story recall more like telling the story, rather than being tested by the same person who had just told it to them, the children told the stories to another familiar local adult who had not been present when the teenager told the story. Despite all these efforts, the Mayan children remembered less of the stories than did the American children. In addition to remembering less information, the Mayan children appeared to be shy and bashful in the story recall situation, and probably that was the reason for lower recall.

Cultural specificity was reported by Kintsch and Greene (1978) who tested American college students on recall of Indian stories. The American subjects did less well in recalling an Indian story than Grimms' fairy tales. Harris, Schoen, and Hensley (1992) also documented the effect of culturally based knowledge on memory for stories about people performing common activities. College students in the USA and Mexico heard three stories of everyday activities. There were two versions of each story, consistent with either an American or a Mexican cultural script. In a delayed recognition test for information in the stories, both groups of students recalled the stories from the other cultures in such a way that they became more like their own culture than they actually were. Similarly, Stefensen and Colker (1982) asked American women and Australian aboriginal women to recall two stories about a child getting sick. In one case the sick child was treated with Western medicine and in the other with aboriginal medicine. Each group recalled the story consistent with their own knowledge better than the other story.

In drawing conclusions about recall in a cross-cultural context, there is a clear evidence that recall of meaningful stories depends much less on schooling experience than recall of unrelated materials. It seems likely that children and many adults rarely use the types of sophisticated strategies that are efficient in learning text material (Schneider & Pressley, 1997). It has been suggested that stories in many cultures have relatively similar structural properties that can mediate in learning and recall (Mandler, 1984). At the same time, there is evidence of cultural specificity. This is further explored in the next section.

4.2.1 Stimulus Familiarity and Cultural Practices

Cross-cultural researchers who supplement their experimental measures of memory performance with ethnographic observations of everyday activities are struck by the difficulty that people have with particular skills in the laboratory, while spontaneously using the skills of interest in their everyday activities (Cole, Hood & McDemott 1978; Rogoff 1981). As a first attempt to make laboratory tasks more culturally appropriate to the population tested, researchers attempted to use familiar materials to enhance the validity of the work. We already mentioned a few studies that directly compared performance on memory tasks when familiar materials versus unfamiliar materials were used.

Familiarity with a stimulus material facilitates input processing and consequently acquiring information. A considerable body of empirical evidence has indicated that increasing the familiarity with stimuli facilitates memory performance (e.g., Lindberg, 1980; Wagner, 1981). A fascinating study by Lancy and Strathern (1981) has shown how familiarity mediates memory and facilitates the deployment of clustering in free recall tasks by children from two societies in Papua New Guinea, that varied in the complexity of the folk taxonomies employed in their language. Ponam folk classification uses taxonomic categories similar to those common in Western societies. In contrast, Melpa folk classification has a paucity of suprageneric terms. Melpa people use a strategy for classification, which they call 'making twos' or grouping things in pairs. For example, color, animal, and plant terms are grouped in pairs of opposites (e.g., light vs. dark, wild vs. planted). On all measures of free recall and clustering in the experiment, Ponam children dramatically outperformed Melpa children. It was considered that Melpa children could not recognize the taxonomic structure of familiar materials, nor use it to sort or cluster. The researchers repeated the study using different stimuli for Melpa and Ponam children (e.g., items that were selected from tighter categories). Melpa children were discovered to behave similarly to the Ponam children on most measures when these stimuli were used. In a similar study Super and Harkness (1981) noted that on free-recall lists designed to reflect taxonomic categories, American adults clustered more than did Kenyan adults, while on comparable lists designed for clustering more on the basis of function, Kenyan adults clustered more. Thus, familiarity with a particular categorizing system appears to benefit recall.

The importance of prior familiarity with to-be-remembered materials has been documented in studies that examine the interaction between knowledge and use of strategies in free-recall tasks. Tarkin (1981, quoted in Mistry, 1997) demonstrated that repetition strategies used by third-graders varied as a function of meaningfulness of the learning material. When third-grade children learned meaningful materials their rehearsal set sizes were as large as those typically produced by sixth-grade children, but the sets were much smaller when they processed relatively unfamiliar materials. Kearins (1983) provided support to the criticality of stimulus familiarity, reporting differences favoring Aboriginal children over other Australian children in verbal recall of wild animals. She argued that Aboriginal children's interest in and knowledge about wild animals promoted their memory in this task. In an earlier study Kearins (1981) required subjects to look at an array of objects for about 30 seconds. Thereafter, the subjects' task was to place the objects back into their array positions. Regardless of the types of objects in the arrays (i.e., technological items like knives and cups or natural items like stones and leaves), the Aboriginal children were consistently better at remembering array locations. These results suggested that Aboriginal children seemed to rely more on spatial-imaginal strategies, whereas Anglo-Australian children were more likely to attempt verbal rehearsal strategies.

As mentioned, results of cross-cultural studies in memory have demonstrated that Western, schooled people generally perform better than non-Western, unschooled people on typical laboratory memory tasks. Cole and Scribner (1977) point out that in contrast anthropological accounts suggest that the memory of non-Western people is quite impressive for information that is culturally important. For example, Micronesian navigators demonstrate extraordinary skills in memory, inference, and calculation in navigating between islands (Gladwin 1970). Similarly, there are exceptional memory feats of Arabs in remembering information about historical events, and the detailed oral information involving the genealogy of families and clans in Africa (D'Azevedo 1982; Mack 1976). In most of such cases, the memory activity is accomplished in the context of a culturally important goal. Thus, meaningful purposes integrate the memory task in an appropriate cultural activity.

Explanations offered for such accounts of outstanding memory among people in societies with oral tradition suggest that lack of a written language or means of record keeping have necessitated a reliance on memorizing large amounts of information, which may have enhanced memory skills of individuals in these societies. However, the extensive experiments conducted by Cole and his colleagues among the Kpelle in Liberia, which were discussed earlier in this chapter, did not support such suggestions. The results did not reveal any generalized superior memory skills among such people compared to American adults (Cole & Scribner, 1977). The explanation for the superior performance of Western people on laboratory memory tasks may lie more in the deliberate effort and use of strategies such as rehearsal and clustering of to-be-remembered materials.

Cultural tools for mathematical operations hold a specific functional role for remembering information related to their use. Japanese abacus experts use internalized representations of the abacus which allow them to calculate mentally without an abacus as accurately as with one (Hatano, 1982). Among Japanese the mental representation of the abacus is extensive and can represent a number of many digits. While abacus experts can recall a series of 15 digits either forward or backward, their memory span for the Roman alphabet and for fruit names is not different from the usual number of chunks of 7 plus or minus 2 that has been found for most adults in memory span tasks. The special processes involved in the impressive mental abacus operations are tailored to the activities in which they were practiced.

Empirical work on cultural differences in spatial memory is rather sparse, but there are nonetheless several findings of superior or equivalent spatial memory performance by non-Western populations compared to Western groups. Kleinfeld (1971) noted better recall for drawn designs among Eskimo children than among urban Caucasian children in Canada. As mentioned before, Kearins (1981) found better recall for spatial arrangement of objects by aborigines dwelling in the Western Desert of Australia than by suburban white Australian youths. The suburban adolescents' performance was especially poor for arrays of objects (sets of different rocks, bottles and knives) that were not easily labeled. The findings of non-Western superiority on spatial tests have been interpreted in terms of the cultural practices such as full-fill the needs of Aborigines and Eskimo people to develop good spatial memory to find their way in environments which appear to the Western eye short of landmarks, and change with wind and storms.

The relatively poor performance of Western individuals on spatial memory tasks may be due to their use of verbal rehearsal strategies, which are not necessarily effective for memorizing spatial information. For example, comparing the methods of memorizing used by the Aboriginal and white Australian children in her studies, Kearins (1986) noted that the Aboriginal children sat still and silent, as if visually memorizing the location of objects in the array, while the white children were restless and seemed to be muttering to themselves as if using verbal rehearsal. Similarly, Rogoff and Waddell (1982) observed that about a third of the 30 American children, but only one of the 30 Mayan children, rehearsed the names of the objects in the panorama as they studied the items to be recalled.

Examples of how institutional and cultural practices may influence memory performance also came from Weisner's (1976) study. Rural children in Kenya outperformed urban children in digit recall. Weisner interpreted this as due to their greater compliance, attentiveness, and deference to the experimenter, which is quite common behavior among children in schools of rural areas, and probably of influence on digit recall and other rote memory tasks. We mentioned already Rogoff and Mistry's (1985) finding that Mayan children's recall of stories was much less than their American counterparts because the Mayan children appeared to be fidgety and bashful in the story recall situation. They were looking at their knees, and their utterances were punctuated with the word 'cha' (which means 'so I have been told'). Apparently, there were important social features of the test situation that made the Mayan children very uncomfortable. It is culturally inappropriate for Mayan children to speak freely to an adult. When carrying messages to adults they must politely add the word 'cha' in order to avoid conveying a lack of respect by claiming greater knowledge than the adult. Thus, it was a strange experience for them to attempt to tell a story to an adult, no matter how comfortable they were with the adult. Retelling a story to an adult is a very familiar situation for children in the USA, where it is one of the tasks of the early school years to teach children to produce and retell narratives to an audience that includes adults (Snow, 1989).

In concluding this section, the performance of an individual in an experiment cannot be considered as a pure reflection of memory capacity. Memory behavior should be seen within the frame of the sociocultural situations in which the individual is used to practice memory functioning. Perhaps the simplest interpretation for the performance differences on spatial tasks is that memory for spatial information does not improve with verbal memorizing strategies. Spatial information may require little deliberate effort to be encoded, and thus people who have little experience in implementing deliberate strategies may not have special difficulties with such tasks.

4.3 Cross-Cultural Research on Metamemory

Metacognitive knowledge enables children to perform better on memory tasks. Also children can benefit from instruction in order to show more durable strategy transfer (see Chapter 3). Unfortunately only few studies on metamemory have been conducted cross-culturally. In a pioneer study Schneider et al. (1986) examined American and German third-grade children on metacognitive knowledge about strategies and the use of newly acquired organizational skills. Pretraining assessment of strategic behavior, a metamemory battery, a general attributional beliefs questionnaire, and a sort-recall task were administered. Subjects were divided in two groups; children in the experimental group were taught how to use taxonomic organization to improve recall on memory tasks. Later on a sort-recall test for words, a metamemory battery and strategy maintenance test were given. The analysis showed somewhat different results for the two groups. American children were more likely to attribute their academic outcome to effort than were the German children. The latter displayed higher levels of spontaneous use of clustering strategy prior to training on the use of a clustering-rehearsal strategy. The American children were superior to German children in memory knowledge after training; US children successfully learned to utilize the strategy to the same extent as the German children. The German children were superior in deploying skills that lead to effective use of metamemorial knowledge.

Carr et al. (1989) assessed the role of the home environment in strategy utilization among German and American children. Samples of American and German children aged 8-9 years were chosen. Children in both countries were given a sort-recall test and a test of metacognition. Subjects in each sample were divided into a training and a control group. Children in the experimental group received group instructions about a strategy that is useful in learning clusterable materials. Children in the control condition were exposed to the training materials but received no explicit instructions. After training, children were tested on the maintenance and far-transfer of the clustering strategy and answered test items from the metacognition battery. Several weeks later parents completed questionnaires about strategy-related experiences in the home. Six months later the children were given a test of taxonomic word clustering to examine long-term strategy maintenance and metacognition.

The results indicated that the German children were more strategy oriented on a sort-recall task than the American children were. These results were compatible with strategy instructions in the home; German parents reported more instruction of strategies than did American parents. Children's metacognition scores were significantly correlated with parent's strategy instructions in both countries. The effects of instructional practice were investigated by comparing the experimental and control groups. American children in the experimental condition showed strategy use and performance superior to American control group both for maintenance and far transfer. German children in the control condition used strategies at a level comparable to that of trained children. The positive findings on the maintenance and generalization tasks in both countries indicate that better instruction in the home and school is important for inducing transfer in young elementary school children.

In India where variability in socioeconomic status (SES) and environmental factors is large, Kurtz, Borkowski, and Deshmukh (1988) studied the home environment and its influence on metacognitive development. Subjects from first and third grade participated in three individual sessions. In the first session children received Raven's Colored Progressive Matrices; in the second session a metamemory test was given; and memory tasks were presented in the last session. Mothers were interviewed twice; teachers at school also were interviewed about classroom instructions and metacognitive teaching styles. The results confirmed previous findings that metamemory is a better predictor of memory performance than other factors such as home environment, SES, children's IQ scores and mothers' IQ scores. However, these data failed to support the hypothesis that a supporting home environment enhances metamemory scores. Quality of the home environment was neither associated with metamemory, nor with genetic factors (as reflected by maternal IQ scores). The results pointed to a difference between Indian and Western children in strategy use. Correlations between strategy use and recall scores were not significant for third-graders, and strategy use was not associated with metamemory at either of the two grade levels. These findings, are in contrast to previous results (cf. Carr et al., 1989; Schneider et al., 1986). Kurtz et al. argued that cross-cultural differences in the use of strategies are possibly related to differences in instructional goals. Such an interpretation was in agreement with teachers' views, which pointed to an instructional emphasis on rote learning, rather than on strategy-oriented learning.

Cultural differences in performance and metacognitive development may be anticipated between societies in which educational environments of the home or school are distinctively different. One example is a difference in causal attribution of achievement found by Salili, Maehr, and Gillmore (1976) in comparing Iranian and American children. Subjects were public school children in Iran aged 7-18 years and American children (the age of American subjects was not described by the authors). The Iranian children chose ability as a reason for successful performance more often than the American children, who preferred effort as the most appropriate explanation

The results of the studies reviewed show that training enhances metamemorial knowledge, and that memory strategies are sensitive to home environment and schooling. Generally, children's cultural environment can induce skills that determine their cognitive and metacognitive development.

4.4 Contributions of Cross-Cultural Research in Memory

Cross-cultural research in general, and cross-cultural research in memory in particular, has often been motivated by interest in testing Western theories for their universality or variability across cultures. Many cross-cultural psychologists have emphasized this goal, claiming the importance of testing the cross-cultural generality of psychological principles before considering them to be established (Segall, Dasen, Berry, & Poortinga, 1990). Typically such studies have used procedures derived from laboratory studies in the Western countries to examine whether people in other cultures perform in a similar manner to their Western counterparts.

Most of this cross-cultural research has examined the relationship of culture and memory using a model in which culture serves as an independent variable and memory serves as an outcome or dependent variable (Rogoff & Mistry 1985). Culture and memory are conceived of as separate variables, and the influence of culture on the individual is typically studied by comparing the memory performance of individuals from two or more different cultures. For example, in a typical free-recall task individuals are presented with lists of words and then asked to recall these. Often the lists contain items from several categories (e.g., food, clothing, and utensils). Individuals from Western countries tend to group items into categories to help in recall or they use other mnemonic strategies such as verbal rehearsal. Evidence from cross-cultural research in the 1960s and 1970s has indicated that individuals from non-Western cultures do not use such mnemonic strategies as frequently, resulting in lower recall of items. However, another picture emerges from memory research in which the specific culture context is taken into account. Evidence from descriptions of non-Western people's memory in their everyday life has suggested better recall in other situations (Bartlett, 1932; Kearins, 1981; Kleinfeld, 1971). A pioneering line of research emphasizing context is the work of Cole and his colleagues described earlier in this chapter (Cole et al., 1971; Cole & Scribner, 1977; Sharp et al., 1979). They used ethnographic methods combined with experimental procedures to elaborate features of the memory tasks and materials that mediated cultural differences in memory performance. The tendency to use laboratory tasks of memory to examine the universality of memory processes was seriously challenged by this work.

In cross-cultural psychology another goal has been emphasized, namely the exploration of variations in psychological functions present in one culture and absent in other cultural settings (Berry & Dasen 1974). Cross-cultural researchers in memory were able to identify variables that are inseparable in Western countries, but separable in other societies. For example, cross-cultural comparisons of memory performance between individuals varying in schooling experience has allowed consideration of the question whether the changes in memory performance observed across childhood in the West are due to experience in school or to maturation (Rogoff, 1981; Sharp et al., 1979). Western children enter school at about age five, and there is a strong confounding between age and grade in school thereafter until adulthood. Hence, there is a danger that 'cognitive-developmental research has been measuring years of schooling, using age as its proxy variable' (Laboratory Comparative Human Cognition, 1979, p. 830). In many non-Western countries, formal schooling is not yet universal, so the relative independence of age and amount of schooling provides investigators with a natural laboratory for investigating the effects of age unconfounded by schooling, or the effects of schooling with age held constant.

Cross-cultural research has demonstrated that performance on free-recall tasks and similar tasks is closely related to the amount of schooling that individuals have received. When non-Western individuals do not perform as well as their Western counterparts, specific aspects of background experience (e.g., formal schooling) can be assumed to explain the difference. But also between Western societies parents and schools seem to provide different amounts of instructions for using memory strategies. As reported before, Carr et al. (1989) demonstrated differences between German and American parents in providing instructions and encouragement to their children in utilizing memory strategies. German teachers also appear to instruct children in schools to be strategic (Kurtz et al., 1990; cf. also Kurtz et al., 1988; Schneider et al., 1986).

4.5 Summary

Cross-cultural research in memory has been conducted to explore not only culture's influence on memory, but also to test the generality of laboratory theories of memory. In contrast to poor performance on Western memory tests, anthropological accounts suggest that the memory of non-Western people is impressive for information that is culturally specific. Studies that have compared the memory of schooled and unschooled subjects consistently showed that children with more schooling have better performance on most (Western) memory tasks, whereas there are few differences in story recall. Performance on memory tasks can be influenced in schooled as well as in unschooled subjects by altering the task or the task context.

Early work on memory was focusing on strategies and only conducted in Western cultures. There is now a realization that some strategies that have commanded great attention in memory development research may be those that are most sensitive to schooling effects. That is, they do not develop at a similar rate universally, but rather are observed more in societies with formal education. Recent work has shown that the child's cultural environment shapes his memory behavior. Culture affects both family life and the nature of schooling thus, with both of these impacting on the development of children's memory competencies.

Part II

Empirical Studies

Chapter 5

Study 1 Memory Span and Reading Speed

5.1 Introduction

In the first part we have seen that memory span has been widely viewed as an important index of mental capacity. It is regarded as a measure of short-term memory, which refers to a hypothetical space that a subject has available for storing information and transforming it (Case et al., 1982). Memory span has been defined as the longest sequence of items that can be recalled in correct order immediately following presentation. In adults, span for a random sequence of letters, digits, or words is about seven items (Miller, 1956). It has been established that memory span improves with age. Bolton (1892) found that between 9 and 14 years, auditory recall of digits improved, and Calhoon (1935) found an increase in the number of digits recalled between the ages 8 and 18 years (quoted in Henry & Millar, 1993).

5.2 Why Memory Span Increases with Age

5.2.1 Item Identification Time

Early research on memory span development with age did not establish the reasons for such improvement. Recently, reasons for the increase in span have been sought. Dempster (1981) did an extensive review of the literature of possible factors in the development of memory span. He concluded that there was little evidence for any factor except item identification speed that can account for the increase in memory span developmentally. The identification time hypothesis proposed by Case et al. (1982) and Dempster (1981, 1985) postulates that there is a limited amount of capacity available to remember items. Case and his colleagues assume that this limited capacity must be shared between the process of identification at input and remembering. The least complicated measure of item identification speed is item recognition time, operationally defined as the minimum amount of presentation time needed for a subject to identify a stimulus (Dempster, 1981). Studies using this measure have focused on comparison across ages. The results indicate that recognition time decreases with age throughout childhood. Identification becomes more rapid with increasing age, leaving more capacity free for remembering items (Case et al., 1982; Dempster, 1981, 1985). Younger children require more effort or time to identify items in a span test, and hence they have less capacity for remembering them.

Item identification time is meant to be a measure of speed of encoding, but it is also closely related to familiarity. Chi (1976) suggested that speed of encoding, or identification time, can be used as a good measure of familiarity and is a key factor in the improvement of span with age. The importance of familiarity was demonstrated by Chi (1978). Children and adults were tested on digit span; the adults performed better. They were also tested on their recall of meaningful chess positions. Here the children performed better. The key point was that the children were relatively 'expert' at chess, whereas the adults were novices. However, no difference was found when the chess positions were random. These results demonstrate the striking effect familiarity can have.

Familiarity effects have been developed to the more general position of 'knowledge-base' as an explanation for memory development (Chi, 1978). Direct evidence that item identification speed is related to span development came from Chi (1977) who compared the recall of adults and 5-year-old children for visually presented familiar (nameable) and unfamiliar (non-nameable) faces. Faces were chosen as stimuli because they were regarded as non-chunkable items. Chi (1977) found that to bring the recall of the 5-year-old to the level of the adults, the latter had to be hampered in several ways: by reducing viewing time, using non-nameable faces, and preventing the use of strategies such as responding first to the faces that were presented last. In addition, the children's recall had to be scored without regard to order. Reduction in viewing time was most important for the identification time hypothesis. The adult subjects were found to retrieve the names of familiar faces twice as quickly as the 5-year-old, suggesting that an advantage in encoding speed was a strong determinant of their higher spans.

Case et al. (1982) argued that there is a limited capacity which does not vary with age, termed 'total processing space' and similar to Pascual-Leone's (1970) M-space assumption. This total processing space must be divided between 'storage space' and 'operating space,' which refers to the storage of information and operations on information, respectively. With age, there is a decrease in the amount of space required for operations. Operations are viewed as processes, such as encoding and retrieval, and with age and practice these become more efficient and require less attentional control. The increase in operational efficiency rests on two assumptions that Case et al. noted: (1) with increased efficiency, attentional load is decreased, and (2) decreased attentional load allows increased speed of processing. Therefore, greater operational efficiency translates itself into greater speed of operations that is revealed in the development of span. Case et al. tested this assumption with children aged 3-6 years. Item identification speed and memory span were obtained for a pool of seven short familiar words. There was an increase with age in both speed of identification and span. A linear function described these increases. Span correlated well with identification speed (r = -0.74) and remained significant when age was partialed out statistically (r = 0.35).

However, Hitch, Halliday, and Littler (1989) did not find that identification time predicted memory span. They measured identification time for auditory and visual items and for memory span, but with older children aged 8 and 11 years. They found that the overall relationships between identification time and memory span for words of different length were not significant. Henry and Millar (1991) matched children aged 5 and 7 years on identification time for familiar words. Span was then tested, on the prediction that if identification time was matched, age differences in span performance should disappear. The usual age differences in span remained even after matching for identification time across age. Thus, the results of this study, which was an explicit test of the identification time hypothesis, did not support it.

5.2.2 *Rehearsal*

As discussed earlier in section 2.2 on rehearsal development, there may be other sources of developmental differences in memory span. Rehearsal is perhaps the simplest strategy that can be used in a deliberate memory task. It is generally viewed as an iterative process, by which information in short-term memory is continually refreshed. Rehearsal's importance is twofold: it maintains information in short-term memory by ensuring a sufficiently high level of activation, and it facilitates the transfer of information to long-term memory and subsequent retrieval of that information by allowing additional time for more elaborate item processing (Dempster, 1981). A variety of measures have been used to investigate the rehearsal process in the context of free- and serial-recall tasks, including overt rehearsal that requires subjects to recite aloud (Ornstein et al., 1975), labial movement measured by close observation and tromygraphic recording (Garrity, 1975), and interitem pause times during list learning (Belmont & Butterfield, 1969). The results provide support for several conclusions:

1. There are developmental changes in rehearsal techniques. Before the age of about 9, children tend to rehearse the item currently being presented either alone or in combination with a minimal number of other items, whereas older children tend to rehearse several items together (Belmont & Butterfield, 1969).
2. There are considerable individual differences in rehearsal activity among both children (Garrity, 1975) and adults (Belmont & Butterfield, 1969).
3. For older children rehearsal activity is positively correlated with the recall of supraspan lists (i.e., lists that exceed the maximum span). Rehearsal activity is correlated with performance in both serial and free recall tasks (Dempster, 1981).

Dempster (1981), commenting on these findings, argued that although rehearsal is an important factor in span differences, none of the findings were obtained by using a memory span task, and many were obtained under conditions involving much slower presentation rates and longer retention intervals than are used in span tasks. Moreover, other findings suggest that the relation between rehearsal activity and recall performance (at least in older children) is due to the enhanced retrieval of rehearsed items from long-term memory, a process that should play an unimportant role in memory span performance. Thus, the observed correlations do not establish that rehearsal is a factor in memory span variance.

Compared to facilitating rehearsal, preventing rehearsal is a more effective method of testing whether verbal rehearsal is the factor that causes age differences in memory span performance (Henry & Millar, 1993). Several experiments have tried to prevent children from using verbal rehearsal in order to determine whether this reduces or eliminates age differences in span. Bebko (1979) prevented rehearsal in two ways: (1) by employing a fast presentation rate, self-paced, but long enough only for the subjects to name each item (to a maximum of 1 sec); and (2) by using a distraction task between presentation and recall. Children aged 6-9 years were classified as verbalizers or non-verbalizers. Despite these attempts to prevent rehearsal, the verbalizers still recalled more than the non-verbalizers, suggesting that it was not only rehearsal which caused improvement in span with age. It may be noted that the age hypothesis was not tested in this experiment, because children were classified as verbalizers or non-verbalizers across age levels.

Frank and Rabinovitch (1974) examined whether rehearsal constitutes a primary determinant of age-related changes in auditory memory. They used running memory span procedures. Subjects are presented with supraspan lists that end unpredictably and have to report as many items from the end of the list as possible. It is assumed that strategies such as rehearsal are not profitable in this task as there is no way of anticipating the end of the list. They compared running span recall to fixed span recall, finding that performance was lower in the running span condition. Age differences disappeared between 10 and 12 year in the running span, but remained between 8- and 10-year-olds. Cohen, Quinton, and Winder (1985) also used the running memory span procedure with children aged 6, 8, and 10 years. They found that age differences were eliminated between 8 and 10 years, but that the 6-year-olds still had lower scores.

Ornstein et al. (1975) studied verbal rehearsal in free-recall tasks. They found that 11-year-old children spontaneously used verbal rehearsal more actively than 8-year-old children did. This manifested itself in rehearsing more items together rather than simply repeating each presented word in isolation. These improvements in rehearsal style were associated with corresponding improvements in recall performance. Ornstein et al. (1977) instructed children aged 8 and 12 years in different types of verbal rehearsal (many-item rehearsal, two-item rehearsal, and one-item rehearsal) and compared these to a spontaneous rehearsal condition. Spontaneously, 8-year-old adopted a one-item rehearsal strategy, which can be regarded as a rather ineffective component of rehearsal (Ferguson & Bray, 1976). By contrast, the 12-year-old rehearsed on average about 3.5 items per group. This confirmed the earlier findings that older children are more active rehearsers than younger children, and that verbal rehearsal training can enhance recall but cannot eradicate age differences.

There is some evidence from these studies that verbal rehearsal may be implicated in the development of span up to 8 or 10 years. However, Dempster (1981) comments that running span may also prevent the use of other strategies. In addition, counting or digit-naming distraction tasks may interfere with recall in other ways than simply preventing verbal rehearsal. Irrelevant tasks may interfere with recall rather than prevent rehearsal. Dempster (1981) and Schneider and Pressley, (1997) have concluded that there is mixed evidence whether or not increase in verbal rehearsal with increasing age can account for developmental differences in memory span. Although the studies of rehearsal generally find increases in verbal activity with age, they cannot address the causal question of whether increases in the use of rehearsal are responsible for the increase in memory span with age. However, verbal rehearsal may be a source of individual differences in memory span, both for children and for adults.

In sum, both indirect and direct methods of studying rehearsal suggest that rehearsal develops gradually and is rare before the age of seven years. As a consequence, verbal rehearsal cannot explain the increase in memory span up to this age. One problem is that rehearsal may occur earlier in some tasks than in others, and that some forms may occur earlier than others. Another problem is that it is not always easy to directly observe the use of rehearsal. Moreover, the distinctions between different forms of rehearsal are not easy. More work is needed on the factors affecting rehearsal and the methods of studying memory span differences.

5.2.3 *Word Length Effect*

One of the most exciting developments and best replicated facts about memory has been the finding that there is a limit to immediate verbal memory. Baddeley (1986) put forth the 'articulatory loop hypothesis' to explain the effects of variation in speech rate due to stimulus and subject variables. In its initial formulation, the articulatory loop was assumed to function like a tape loop of limited duration. The loop is a temporary storage of speech based material with a duration of two seconds, and capable of maintaining its content by means of rehearsal. The main assumption is that the more quickly the subject can articulate items, the more items can be refreshed in memory before decay beyond a critical point. In the context of a memory span task, the subject is faced with a decaying memory trace of the items presented, and uses the articulatory loop to recycle the items and refresh the decaying trace. Because the trace decays at a constant rate, items that can be rehearsed quickly, can be maintained. In this way the number of items recalled is directly related to the speed of rehearsal in the articulatory loop.

Baddeley, Thomson, and Buchanan (1975) have demonstrated that the immediate memory span for short words is larger than for long words. The memory span for words that take a short time to articulate is greater than that for words that take a long time to articulate. The correlation between rehearsal rate (measured as reading rate) and memory span reflects the fact that fast rehearsers can rehearse words in the limited time available to refresh traces in the phonological store. Baddeley et al. considered the memory span as an estimate of the time duration of the phonological store. This duration was approximately 1.6 sec regardless of word length. Schweickert and Boruff (1986) have found a similar effect with a variety of different materials. Evidence has accumulated that differences in immediate memory across individuals, across different materials, across age and across languages can be accounted for largely on the basis of differences in the rate at which items can be pronounced (Schweickert, 1993).

The articulatory loop model has also been applied developmentally (Baddeley, 1986; Halliday & Hitch, 1988; Hitch, Halliday, Dodd, & Littler 1989; Nicolson, 1981). The basic proposition is that children have slower speech rates than adults, so they rehearse more slowly. With age, increase in speech rate allows faster speed of rehearsal leading to better recall. Evidence to support this position comes from the linear relationship that was found between speech rate and memory span for children of different ages.

Nicolson (1981) tested three groups of 10 children aged 8, 10, and 12 years on memory span and reading rate. The average memory span and reading rate were lower than for adults, but improved with age. For each age group both memory span and reading rate decreased as the number of syllables of the stimuli increased. The within-group correlations between memory span and reading rate were .71, .51, and .66 for ages 8, 10, and 12, respectively. When memory span and reading rate means for each number of syllables were plotted, the relationship was linear for each of the three age groups.

Hulme, Thomson, Muir, and Lawrence (1984) examined the effect of word duration (i.e., the time it takes to pronounce a word) on memory span in subjects of different ages. The same linear function relating recall to speech rate (assessed by the speed of repeating words) fitted the results of subjects ranging in age from 4 years old to adulthood. In a similar study, Hulme and Tordoff (1989) examined the effect of word length and acoustic similarity on speech rate and serial recall in children ranging in age from 4 to 10 years. Children of different ages showed a word length effect and there was an increase in recall with age. In the case of words of different length, differences in recall were closely related to the rate at which they could be spoken. Hitch et al. (1989) also investigated word length effects in children of different ages. Short-term recall showed a word length effect; words that take longer to pronounce were recalled less well than words that can be said more quickly; thus three-syllable words result in poorer recall than one-syllable words. Correlations between articulation rate and recall across materials were positive.

The relevance of the relationship between articulation rate and memory span for cross-cultural and cross-linguistic research is that memory span should vary across languages that differ in the time to read a given set of items. This prediction has been confirmed in studies comparing languages that differ in word length in terms of number of syllables and in number of phonemes. Observations led to the suggestion that it takes longer to articulate digits in Welsh language than their English equivalents. Ellis and Hennely (1980) tested bilingual adult subjects on a memory span and reading speed task. Subjects were required to read aloud 20 lines of digit numbers as fast as possible eight times, altering the language on each trial. Reading time for the digits was recorded on each trial, and a mean time calculated for each language. There was a significant difference in reading speed for the two languages. The mean reading time for the 200 digits in Welsh was 77.1 sec., compared with 64.2 sec in English. It took an average of 385 ms to read a Welsh digit compared with 321 ms to read an English digit. These findings led to the prediction that the subjects would have a greater memory span for English digits than for Welsh digits. It has been found that memory span for English was 6.55 vs. 5.77 items for Welsh. The correlation between digit reading speed and the memory span was significant. These results confirm Baddeley et al.'s (1975) hypothesis, according to which a subject's span is the number of words that can be read in approximately 2 sec, and parallel to this that there is a significant correlation between a subject's reading speed and his or her memory span.

Memory span has been employed in a number of other cross-cultural studies. Stigler, Lee, and Stevenson (1986) compared children from Japan, Taiwan, and United

States in kindergarten, first grade, and fifth grade on a digit span test. They found that the Japanese and American distributions are similar to each other, but differ greatly from the distribution of the Chinese children. Among the Chinese children, a span of 7 digits was found for 37% of the kindergartners, 68% of the first graders, and 92% of the fifth graders. The mean digit span of the Chinese, Japanese and American children in kindergarten were 5.9, 4.1 and 4.6 respectively, 6.4, 4.4 and 5.1 for the first graders, and 6.9, 5.5 and 5.9 for the fifth graders. The explanation for the markedly different distribution of Chinese children is that there are differences in the time required to pronounce number words in the languages involved.

Zhang and Simon (1985) compared bilingual Chinese subjects on their memory span of Chinese and English digits. The subjects were six scholars. Twenty spoken lists of Chinese and English digits were recorded on a tape. The length of Chinese lists ranged from 4 to 13 digits; the English digits ranged from 2 to 11 digits. Both Chinese and English lists were recorded from the shortest to the longest. All lists were spoken at a rate of about 750 ms per digit. Responses were oral; span was assessed as number of digits recalled correctly in serial order. The span for Chinese digits was 9.50 items and for English digits 5.67 items. Subjects were able to recall many more Chinese than English digits. Interestingly, the subjects' span for the English digits was comparable to the typical span of English-speaking adults. When they were asked about their recall of digits, every subject reported that it is easier to remember Chinese digits than English digits. One subject said that Chinese digits sounded clearer and seemed to last longer than English digits after a digit list was heard.

Naveh-Benjamin and Ayres (1986) conducted a study with adult English, Spanish, Arab and Hebrew speakers. Their ages were between 20 and 30 years. Subjects were tested on digit span, speeded digit reading and story reading speed. The findings confirmed the relationship between articulation rate and immediate memory span. The actual memory span for the English, Spanish, Hebrew, and Arab was 7.21, 6.37, 6.51, and 5.77 digits respectively; and the speeded digit reading for the English, Spanish, Hebrew and Arab was .256, .287, .309, and .370 sec per digit, respectively. These results indicated that the word length effect reported for differences within a language applies to differences between languages as well. The finding shows that in the digit span task, span was highest in English and lowest in Arabic. For the speeded digit-reading task, also the fastest rate was in English and the lowest in Arabic. The normal pace story reading task showed results in the same direction as those obtained for digit span and speeded digit reading, with English faster and Arabic slowest.

All in all, the concept of articulatory loop was applied to a range of phenomena, from the role of phonological coding in learning to cultural differences in memory span and arithmetic performance. Children of different countries vary in their mathematical skills as well as other cognitive processes. The concept of articulatory loop suggested a possibility hardly considered before, namely the role of language differences in number words. Miller and Stigler (1987) showed that the structure of number words in most

Asian languages, such as 'ten one' for eleven, makes counting easier for Asian children relative to American children. The structure of Asian-language number words may facilitate the understanding of basic arithmetic in terms of place value (Fuson & Kwon, 1991). Various studies, discussed in this section have shown that the speed with which numbers can be pronounced in different languages appears to influence national differences in memory span for numbers.

5.3 Hypotheses

The purpose of the present study was to investigate the performance of Libyan children in word and digit span tests compared to Dutch children. Most modern languages, including Arabic have base ten number system, that is they have separate number names only for the first ten numbers corresponding to the ten fingers used for counting. Beyond ten the cycle of number names begins all over again. For example, in Arabic the word eleven came from a version of 'one and ten' and twenty came from 'two tens.' The Arabs adopted this number system that has been invented by the Hindus of India a long time ago. The new system, called Arabic numerals that consist of nine different symbols: 1, 2, 3, 4, 5, 6, 7, 8, and 9. The Arabic language has one word for each digit, those most often used for counting. The Arabic names for such numbers are wahad, 'thnayn, thalatha, 'arba3a, khamssa, sitta, sabaa, thamaneya, and tessaa. Compared with Dutch digit names that use these nine symbols to represent, een, twee, drie, vier, vijf, zes, zeven, acht, and negen (Horn & Brinck, 1998). The Arabic number words are likely to require longer reading times than the Dutch. Many of the Arabic number words have three syllables, while the Dutch numbers have only one or two. There is another feature of Arabic numerals that makes them highly suitable to test the phonological loop hypothesis in a single language. In Arabic language there are two ways to pronounce digits. One is long, and the other is relatively short. Primary school textbooks in arithmetic can document such distinction. Both types of pronunciation are common among school children. Libyan children as well as other Arab children in schools are using both ways of pronunciation. This provides the opportunity for a very direct test of the word length effect on memory span, keeping subjects language and the meaning of stimuli constant, and only varying the length of the stimulus words.

Also, the present study can extend the study of memory span with children cross-culturally. The comparison of Dutch and Libyan children on memory span tasks as related to reading speed allows us to be more accurate in estimating quantitative aspects of the variables, and it enables us to examine the relationship between word length, pronunciation rate, and memory span. In addition, the study of memory span of children in their cultural context may provide insights important for practical reasons. Measures of intelligence that rely in part on short-term memory such as the Wechsler's Intelligence Scale for Children, may need to have norms adjusted according to the language of the testee (Ellis & Hennely, 1980). Differences in memory span could influence the demonstration of arithmetic skills. Also, differences in reading rate may affect the time it takes to complete a wide variety of reading tasks.

The study was undertaken in Libya and the Netherlands for various reasons. The researcher who is Libyan, has extensive knowledge of the culture, language (which is Arabic) and the demography of Libya. The selection of the Netherlands was due to the fact that the researcher studied in this country.

The specific hypotheses to be tested are mainly related to the word length effect and age differences. The Libyan data were initially analyzed separately. In a first hypothesis (*H1*) we expected that memory span increases with age. This hypothesis applies to four measures (short-digits, long-digits, short-words and long words) of memory span. In addition, we hypothesized (*H2*) that, across age groups, there is no gender difference in memory span. A word length effect was postulated (*H3*), in particular, memory span for short words is larger than for long words.

The study also tested the word length effect cross-culturally using three measures. Memory span and reading speed of Libyan and Dutch children were tested on short-digits, short-words and long-words. It was expected that there are developmental increases in memory span and reading speed in both Libyan and Dutch groups across the three measures (*H4*). Gender differences were not expected across the measures of memory span and reading speed (*H5*). Finally, the expectation was tested that differences in memory span could be explained in terms reading speed using a structural equation model (*H6*).

5.4 Method

5.4.1 Subjects

The Dutch sample consisted of 40 subjects and was taken from two elementary schools in villages of a semi-urban area of the Netherlands, close to Tilburg. Subjects were recruited from third and fifth grades. Of both schools five boys and five girls of eight years of age and five boys and five girls of ten years of age were selected. All subjects were Dutch residents, and native speakers of the Dutch language, and they came from middle-class families. The Libyan group consisted of 64 subjects chosen from two elementary schools in Garian, a semi-urban area of the western part of Libya. Subjects were recruited from third and fifth grades. Of both schools 14 boys and 18 girls of eight and nine years of age and 16 boys and 16 girls of ten years of age were involved. All Libyan subjects speak only their native language, which is Arabic. The subjects came from middle class families in Garian.

5.4.2 Material and Procedures

5.4.2.1 Memory Span Tests

The memory span tests were made up of two subtests, digits and words respectively. The Arabic version of the digits test was subdivided in a test with short digits and a test with long digits. The words test in both languages was subdivided in a test with short words and a test with long words.

Digit Span Test Digits were selected randomly from the set of 1-9. Zero (0) was excluded because it is ambiguous in meaning and pronunciation for children. There were seven lists with three trials each. In order to prevent floor and ceiling effects the length of the trials ranged from two to eight digits, increasing one digit per list sequentially. No digits were repeated in a trial; no successive numbers (e.g., 2-3) followed each other, and sequences of numbers that contain mnemonic cues were avoided (e.g., phonological similarity, such as in Dutch, between the numbers 7 and 9). Two forms, a form with short number words and a form with long number words, were used with the Libyan subjects.

In order to standardize the stimulus presentation, digits and instructions were read in Arabic and Dutch respectively by two female teachers (native speakers) and recorded on tape. Subsequently these analog recordings were digitized and edited by means of the 'WaveStudio' computer program. With this application every single digit could be manipulated to arrange the digits in any order and with any time interval so as to construct the various lists. Once all the required lists had been composed they were copied to audiotape. The end of every trial was marked by a tone ('ding') and the end of a list by a different one ('chimes').

Procedure Each subject was tested individually. Two tape-recorders were used during the session, one to present the prerecorded instructions and lists of digits to the subject and one equipped with a microphone to record the responses of the subject. At the beginning of a session the subject was told by the experimenter to listen carefully to the instructions and to the lists of digits on the tape recorder. The subject had to recall the digits in the same order as presented. To show the subject how to proceed on a task, a training session was held by presenting three trials with a length of three digits per trial and three trials with four digits per trial.

After the training session, the experimenter continued with the actual test session by running the tape starting with the first list that contained two digits. The presentation of lists continued as long as the subject recalled correctly in a serial order the digits in all three trials of a list.

When the subject failed to recall the digits on three consecutive trials of a list, the test was terminated. If the subject had been able to recall all the digits for only one of three trials of any one list, the test was stopped and recall was scored as the number of digits recalled correctly in the preceding list (list length) plus a bonus of 0.5; for example, a subject who could recall correctly the complete list (three trials) of five digits and only one trial of six digits, received a score of 5.5. If the subject had been able to recall all the digits on two out of three trials of any one list, the test was stopped and recall was scored as the length of that very list; for example, a subject could recall correctly not more than two trials of five digits, the score was 5.

Word Span Test Two sets of familiar Arabic and Dutch words were assembled from large pools of words. These were evaluated for their familiarity by Dutch and Libyan preparatory teachers, respectively. The two sets in each language differed in word length as measured by number of syllables, i.e., two and three syllables, for the Dutch words; three and four syllables for the Arabic words, respectively. So, in both languages one set consisted of eight short words and the other set of eight long words. The words in each language were read by a female teacher at a rate of approximately one word per second; and constructed in seven lists of three trials each. The list length increased from two to eight words sequentially. Lists of different lengths were prepared in the same way as described for the lists of digits.

Procedure Two sessions were devoted to the assessment of memory span for each of the two sets of words. The first session included a preliminary task in which the subject was asked to repeat each item to ensure that the subjects could repeat the material without difficulty. In the second session, the experimenter presented the words successively, by playing the tape with the prerecorded stimulus material. The subjects were instructed to listen to the entire trial, and start to respond after the tone. Three trials at each list length were presented. Each time the list length increased, the subject was informed that he/she was going to get a longer list. Word presentation began with a two-word list; if recall was correct, a list of three words was presented next. If recall was not correct, another trial of the same length was presented. This incremental procedure continued until an error was made on three successive trials of the same length. Then the span test was terminated. Memory span equals this final length, plus a bonus of 0.5 if one trial at the next list length was correctly repeated. For example, a subject who recalled correctly all the trials of three items and one trial of four items received a score of 3.5. If the subject was able to recall all the words on only two out of three trials at any list length, the test was stopped and recall was scored as the length of that very list. For example, a subject who could recall correctly not more than two trials of five words, was given a of 5.

5.4.2.2 Speed Reading Tests

The Speed-Reading Test was made up of two subtests, for digits and words respectively. The words test was divided in short words and long words for the Dutch subjects. And both the digit and word tests were divided in short and long forms for the Libyan subjects.

Speeded Digit Reading In order to provide data about speech rate (reading speed) of the subjects in the study, the lists of digits and words were read aloud by them and as quickly as possible. Speech rate is operationalized as the number of items a subject can say in one second (items/sec). The digit reading test consisted of eight pairs of digits typed in medium size fonts, each pair on a separate sheet. A tape recorder with a microphone was used for recording.

Procedure After a check whether the subject was capable of performing the task, the experimenter asked him or her to read and repeat again and again, aloud and as quickly as possible, each pair of digits presented by the experimenter. When the subject was ready to start, the experimenter presented the first pair, after having started the recorder to tape the subject's reading. Each pair of digits was to be repeated ten times; the counting was done (silently) by the experimenter. No instruction was given to the subject about the number of repetitions. Young children tend to keep on reading instead of articulating the words/digits as quickly as possible. That is why the pair was presented to the subjects on a separate sheet and why they were asked to repeat the pair as quickly as possible without reading the digits from the sheet. So subjects did not read the pairs of digits but repeated them from memory. As in the memory span testing session described before, counterbalancing was applied in order to compensate for order effects.

Speeded Word Reading The test of speed word reading was designed to provide data about the maximum speech rate of subjects. They were asked to read aloud, as quickly as possible, lists of familiar words, and their reading speed was recorded. Reading speed is defined here as the number of specified words a subject can say in one second. The same two sets of short and long words that were used in the span test were grouped in pairs, resulting in four word pairs of short words and four long word pairs. Each of these pairs of words was typed in medium size fonts on a separate sheets. A tape recorder with a microphone was used to record the entire session.
Procedure The procedure for this subtest was the same as for the Speeded Digit Reading and was applied to both short and long words. The recorded performance of the subjects on both the Speeded Digit Reading test and the Speeded Word Reading test was digitized by copying them from the analogue audio-tape to the hard disk of a Personal Computer. Subsequently, individual trials were selected and edited with the 'WaveStudio' program. This program provides a rather precise measurement device (milliseconds) for audio-signals. These are converted to a graphical representation, which can be edited visually. The mean reading speed per trial was determined and copied subsequently to an SPSS database for further statistical analysis.

5.4.3 Statistical Analyses

The following statistical analyses were carried out: (*1*) Analyses of Variance (multivariate and repeated measures) were used to test differences in memory span and reading speed as a function of age, gender, and culture; (*2*) A Structural Equation Model was used to examine reading speed as a predictor of memory span, and (*3*) ANCOVA (Analysis of Covariance) was used to test the adequacy of the articulatory loop model in explaining age, gender, and cultural differences in memory span scores, using reading speed scores as a covariate.

5.5 Results

The first analysis involved the Libyan data. An analysis of variance with repeated measures was used. Age (2 levels: 8 year-olds vs. 10 year-olds) and gender (2 levels: boys vs.

Table 5.1 Analysis of Variance (Repeated Measures) of Memory Span in the Libyan Sample (Estimated Effect Size, η^2, in Last Column)

Source	*F*	*df*	*p*	η^2
Between				
Age	7.32	1, 60	.01**	.11
Gender	5.64	1, 60	.02*	.09
Age x Gender	0.20	1, 60	.66	.00
Within				
Word Length (short-long)	19.30	1, 60	.00***	.24
Age x Word Length	0.49	1, 60	.49	.01
Gender x Word Length	0.26	1, 60	.61	.00
Age x Gender x Word Length	2.63	1, 60	.11	.04
Digits-Words	56.73	1, 60	.00***	.49
Age x Digit-Word	0.56	1, 60	.46	.01
Gender x Digit-Word	2.07	1, 60	.16	.03
Age x Gender x Digit-Word	0.37	1, 60	.54	.01

*$p < .05$. **$p < .01$. ***$p < .001$.

girls) were the between-subjects variables while stimulus modality (2 levels: words vs. digits) and stimulus length (2 levels: short vs. long stimuli) were the within-subjects variables. The analysis confirmed the age hypothesis (*H1*) and showed a significant main effect of age, $F(1, 60) = 7.32, p < .01$, the proportion of variance accounted for by the factor, η^2, was .11 (Table 5.1).

The average mean score of the older Libyan children (10 year old) on the four measures of memory span was 3.70, while the mean score of the younger children (8 year old) was 3.45 (see Table 5.2). Contrary to expectation (*H2*), a significant difference was found between boys and girls ($F(1, 60) = 5.64, p < .05, \eta^2 = .09$); the girls scored on average higher than the boys on the memory span measures (means of 3.67 and 3.46, respectively). A significant effect for word length was found ($F(1, 60) = 19.30, p < .001$), explaining not less than 24% of the variation. In line with the third hypothesis (*H3*), memory span for short words was larger (3.43) than that for long words (3.28). There was a highly significant difference between digit span and word span ($F(1, 60) = 56.73, p < .001, \eta^2 = .49$); children's digit span was longer than their word span. No interaction effects were significant.

The next analysis addressed, among other things, country differences. As only one type of digits could be used in the Dutch sample, a repeated measures analysis of variance with a crossing of modes and length of stimuli could not be carried out. Therefore, a multivariate analysis of variance was carried out on the combined data of Libyan and Dutch groups. Independent variables in the multivariate analysis of variance were age (8 vs. 10 year), gender (boys vs. girls), and culture (Dutch vs. Libyan); the dependent variables were memory span for digits (i.e., short digits for the Libyan pupils), short words, and long words.

Table 5.2 Means of Memory Span and Reading Speed Tests per Age and Gender (Libyan Sample)

Variables	Means				
	Age		Gender		
Test	8	10	Boys	Girls	*Overall*
Memory Span					
Short Digits	3.77	4.05	3.73	4.06	*3.91*
Long Digits	3.53	3.81	3.53	3.79	*3.67*
Short Words	3.56	3.50	3.35	3.50	*3.43*
Long Words	3.14	3.42	3.22	3.34	*3.28*
Overall	*3.45*	*3.70*	*3.46*	*3.67*	*3.56*
Reading Speed					
Short Digits	2.14	2.53	2.41	2.28	*2.34*
Long Digits	1.30	1.57	1.44	1.43	*1.44*
Short Words	1.48	1.81	1.67	1.62	*1.65*
Long Words	1.30	1.59	1.46	1.43	*1.45*
Overall	*1.56*	*1.88*	*1.74*	*1.69*	*1.72*

The results are presented in Table 5.3. The analysis showed a large effect for age (Wilks' lambda = .82, $F(3, 94) = 7.00, p < .001$), explaining 18% of the variance; older children's memory span was larger than that of younger subjects. Univariate F tests of each of the separate tasks of memory span showed that this effect could be attributed to age effects on digit span ($F(1, 96) = 12.63, p < .001, \eta^2 = .12$) and long words span ($F(1, 96) = 16.15, p < .001, \eta^2 = .14$). Older children scored higher than younger subjects on memory span for digits, the mean score was 4.42 for the older and 4.00 for the younger children. The average span of long words of ten-year-old children was 3.60, which is larger than 3.22 for the eight-year-old subjects (see Table 5.4). In sum, the data confirmed the hypothesis (*H4*) that memory span increases with age for digit span and long words; for short words the difference was in the predicted direction but failed to reach significance.

Gender differences on memory span were not significant on the multivariate level, including all measures of memory span. A univariate test showed a significant gender difference in digit span ($F(1, 96) = 6.90, p < .01, \eta^2 = .07$), contrary to expectation (*H5*). The multivariate F value for the main effect of culture was significant and large, explaining 24% (Wilks' lambda = .76, $F(3, 94) = 10.02, p < .001$). Each univariate F test showed significant country differences: digit span ($F(1, 96) = 30.07, p < .001, \eta^2 = .24$), short word span ($F(1, 96) = 9.47, p < .01, \eta^2 = .09$) and long word span ($F(1, 96) = 7.49, p < .01, \eta^2 = .07$). No significant multivariate or univariate F values were found for any interaction. In the analysis using a structural equation model the interpretation of these culture differences is further examined.

Table 5.3 Multivariate Analysis of Variance of Memory Span (Estimated Effect Size, η^2, in Last Column)

Sources	Wilks' lambda	*F*	*df*	*p*	η^2
	Multivariate tests				
Age	.82	7.01	3, 94	.00***	.18
Gender	.93	2.42	3, 94	.07	.07
Culture	.76	10.02	3, 94	.00***	.24
Age x Gender	.99	0.03	3, 94	.99	.00
Age x Culture	.99	0.45	3, 94	.72	.01
Gender x Culture	.99	0.25	3, 94	.86	.01
Age x Gender x Culture	.96	1.46	3, 94	.23	.05
	Univariate tests				
Age	Short Digits	12.63	1, 96	.00***	.12
	Short Words	2.94	1, 96	.90	.03
	Long Words	16.15	1, 96	.00***	.14
Gender	Short Digits	6.90	1, 96	.01**	.07
	Short Words	1.13	1, 96	.28	.01
	Long Words	0.36	1, 96	.54	.00
Culture	Short Digits	30.07	1, 96	.00***	.24
	Short Words	9.47	1, 96	.01**	.09
	Long Words	7.49	1, 96	.01**	.00
Age x Gender	Short Digits	0.02	1, 96	.88	.00
	Short Words	0.03	1, 96	.85	.00
	Long Words	0.00	1, 96	.96	.00
Age x Culture	Short Digits	0.79	1, 96	.37	.01
	Short Words	0.10	1, 96	.74	.00
	Long Words	0.95	1, 96	.33	.01
Gender x Culture	Short Digits	0.09	1, 96	.76	.00
	Short Words	0.14	1, 96	.70	.00
	Long Words	0.75	1, 96	.38	.00
Age x Gender x Culture	Short Digits	3.07	1, 96	.08	.03
	Short Words	0.24	1, 96	.61	.00
	Long words	0.04	1, 96	.82	.00

$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 5.4 Means of Memory Span and Reading Speed Tests (i.e., Number of Words Read per Second) per Age, Gender, and Culture

Variables	Means					
	Age		Gender		Culture	
Test	8	10	Boys	Girls	Libyan	Dutch
Memory Span						
Digits	4.00	4.42	4.06	4.37	3.89	4.54
Short words	3.50	3.69	3.53	3.65	3.42	3.76
Long words	3.22	3.60	3.38	3.44	3.28	3.54
Overall	*3.57*	*3.90*	*3.66*	*3.82*	*3.53*	*3.95*
Reading Speed						
Digits	2.58	2.90	2.87	2.61	2.34	3.14
Short words	1.75	2.00	1.96	1.79	1.64	2.11
Long words	1.42	1.68	1.60	1.51	1.45	1.66
Overall	*1.92*	*2.19*	*2.14*	*1.97*	*1.81*	*2.30*

The analysis of variance of reading speed (Table 5.5) showed a significant multivariate F value for the main effect of age (Wilks' lambda = .70, $F(3, 94) = 12.97$, $p < .001$, $\eta^2 = .30$), gender (Wilks' lambda = .86, $F(3, 94) = 5.12$, $p < .001$, $\eta^2 = .14$), and culture (Wilks' lambda = .40, $F(3, 94) = 47.35$, $p < .001$, $\eta^2 = .60$). Univariate F tests showed a main effect of age for digit speed ($F(1, 96) = 15.12$, $p < .001$, $\eta^2 = .14$), short words speed ($F(1, 96) = 22.40$, $p < .001$, $\eta^2 = .19$) and long words speed ($F(1, 96) = 38.00$, $p < .001$, $\eta^2 = .28$). As can be seen in Table 5.4, reading speed increases with age, supporting the hypothesis that reading speed of older children on all measures is greater than that of younger children (*H4*). The univariate F test showed that a main effect of gender was present for digit reading speed ($F(1, 96) = 10.49$, $p < .001$, $\eta^2 = .09$), short words reading speed ($F(1, 96) = 10.72$, $p < .001$, $\eta^2 = .10$), as well as long words reading speed ($F(1, 96) = 4.41$, $p < .04$, $\eta^2 = .04$). Boys scored higher than girls on all reading speed measures (see Table 5.4). The hypothesis of no gender differences on reading speed (*H5*) was not supported.

Table 5.5 Multivariate Analysis of Variance of Reading Speed (Estimated Effect Size, η^2, in Last Column)

Sources	Wilks' lambda	F	df	p	η^2
	Multivariate tests				
Age	.70	12.97	3, 94	.00***	.29
Gender	.86	5.12	3, 94	.00***	.14
Culture	.40	47.35	3, 94	.00***	.60
Age x Gender	.99	0.06	3, 94	.97	.00
Age x Culture	.92	2.52	3, 94	.06	.08
Gender x Culture	.92	2.71	3, 94	.05*	.08
Age x Gender x Culture	.99	0.38	3, 94	.72	.01
	Univariate tests				
Age	Short Digits	15.12	1, 96	.00***	.14
	Short Words	22.40	1, 96	.00***	.19
	Long Words	38.00	1, 96	.00***	.28
Gender	Short Digits	10.49	1, 96	.00***	.09
	Short Words	10.72	1, 96	.00***	.10
	Long Words	4.41	1, 96	.04*	.04
Culture	Short Digits	93.17	1, 96	.00***	.49
	Short Words	79.59	1, 96	.00***	.45
	Long Words	24.07	1, 96	.00***	.20
Age x Gender	Short Digits	0.03	1, 96	.84	.00
	Short Words	0.14	1, 96	.70	.00
	Long Words	0.18	1, 96	.66	.00
Age x Culture	Short Digits	0.52	1, 96	.47	.01
	Short Words	2.99	1, 96	.08	.03
	Long Words	0.15	1, 96	.70	.00
Gender x Culture	Short Digits	3.53	1, 96	.06	.04
	Short Words	7.42	1, 96	.01**	.07
	Long Words	3.61	1, 96	.06	.04
Age x Gender x Culture	Short Digits	0.56	1, 96	.45	.01
	Short Words	0.02	1, 96	.89	.00
	Long words	0.01	1, 96	.90	.00

*$p < .05$. **$p < .01$. ***$p < .001$.

The main effect of culture can be attributed to differences in reading speed for in digit ($F(1, 96) = 93.17, p < .001, \eta^2 = .49$), short words ($F(1, 96) = 79.59, p < .001, \eta^2 = .45$), and long words ($F(1, 96) = 24.07, p < .001, \eta^2 = .14$). Table 5.4 shows that the Dutch children scored higher than the Libyan subjects on all reading speed tests. It may not be superfluous to repeat that the stimuli for the Dutch and Libyan children were not identical; as a consequence, differences in mean scores are not easy to interpret.

The multivariate F value for the interaction effect of gender by culture reached significance (Wilks' lambda = .92, $F(3, 94) = 2.71, p = .05, \eta^2 = .08$). Univariate F tests showed that this interaction effect was present only for short words reading speed ($F(1, 96) = 7.42, p < .01, \eta^2 = .07$). Gender differences were larger in the Dutch sample; whereas the mean scores on short words reading speed of the Libyan girls and boys were 1.62 and 1.67, respectively; the mean scores of the Dutch girls and boys were 1.95 and 2.26.

Structural Equation Modeling The relationship between reading speed and memory span measures was examined using a Structural Equation Model (SEM). Two analyses were carried out. The first focused on the Libyan data and involved all eight tests; the second examined the six tests that were administered in both countries. The Dutch measures of digits were taken to correspond to the short digits task in the Libyan group, because the Dutch reading speed averages were closer to the short digits reading speed than to the long digits reading speed of the Libyan group. The covariance matrices to be analyzed were based on deviance scores. In the previously reported analyses of variance, significant effects were found for age, gender, and culture. In order to avoid uncontrolled aggregation effects on the covariances, it would be recommendable to split up the SEM analyses according to age, gender, and culture. However, the sample size did not allow for such a split. As an alternative, covariances for aggregated data were computed by taking deviance scores, controlling for age, gender, and culture (the latter effect was immaterial for the first analysis in which only Libyan data were involved).

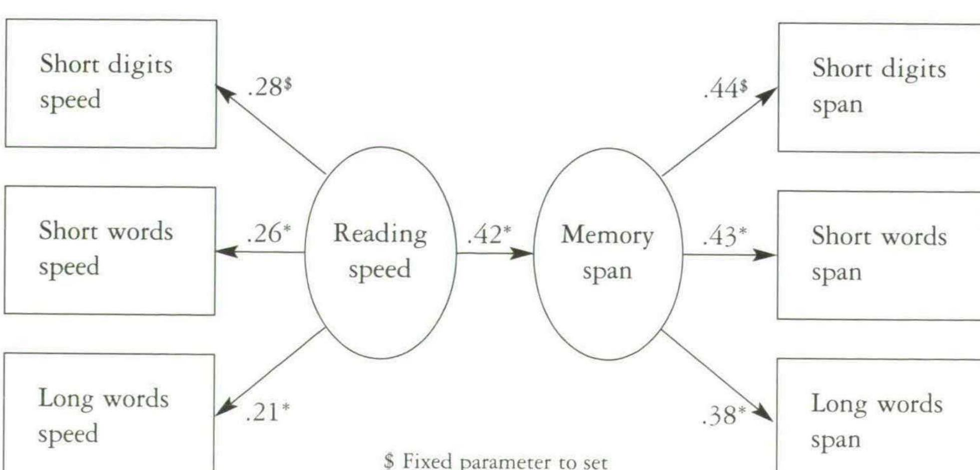

Figure 5.1 Structural equation model linking reading speed and memory span in the Libyan sample (standardized solution)

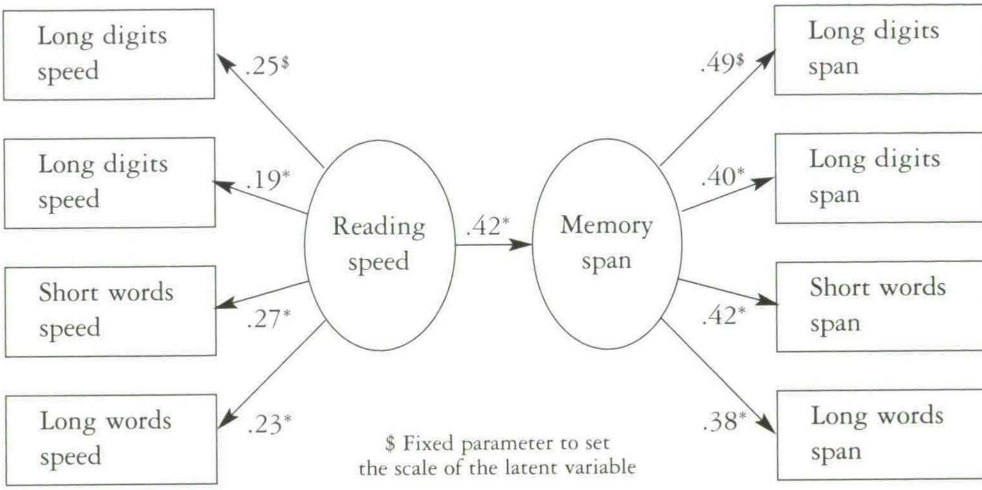

Figure 5.2 Structural equation model linking reading speed and memory span in the combined samples (standardized solution)

The speed measures can be taken to compose a single latent speed factor, while the span measures define a memory span factor. According to the articulation loop model, the speed factor should impact on the memory span factor. In SEM terms, this means that the reading speed measures are the observed input variables which together compose a latent factor, similarly, a latent memory span factor is defined by the observed output measures. Finally, there is a path from the speed factor to the span factor.

The results of the first analysis are presented in Figure 5.1. A good model fit was found, $\chi^2(19, N = 64) = 28.18, p = .08$, RMSEA = .09 (90% interval: 00-.15), CFI = .97, NNFI = .96. As could be expected, all speed measures showed a positive and significant loading on the latent reading speed factor ($p < .01$). Similarly, all span measures showed a positive and significant loading on the memory span factor ($p < .01$). The path coefficient of reading speed on memory span was also significant, g = .86, $p < .01$. Reading speed explained 17% of the variance of memory span, which is significant though moderate.

The second SEM analysis, leaving out the tasks for the long digits and involving both the Libyan and Dutch subjects, largely yielded a similar picture (see Figure 5.2). The fit was excellent: $\chi^2(8, N = 104) = 7.06, p = .53$, RMSEA= .00 (90% interval: .00-.11), CFI = 1.00, NNFI = 1.00. All factor loading were positive and significant, $p <$ .01. The path coefficient was significant, g = .75, $p < .01$. Again 17% of the variance of memory span factor was explained by reading speed. The hypothesis that differences in memory span could be explained in terms reading speed using a structural equation model was clearly supported (*H6*).

The SEM analyses underscored the feasibility of the phonological loop hypothesis. Both the reading speed and the memory span measures defined their own underlying factor and these two factors showed a significant relationship. Children who have a higher reading speed tend to show a better performance on the memory span tasks.

Analysis of covariance The present data provide an interesting test of the strong claims of Baddeley's model according to which reading (pronunciation) speed provides an explanation of, among other things, individual, age, and language differences in memory span (cf. Schweikert, 1993). Such a strong claim seems to run counter to our finding in the SEM analysis that only 17% of the variation in memory span could be accounted for by reading speed. In a subsequent analysis the question was addressed to what extent the claims of Baddeley's model were materialized in the present study. An analysis of covariance was carried out, with the three memory span measures as dependent variables and reading speed as covariate; like in the previous multivariate analysis of variance, independent variables were culture, age, and gender. The results have been presented in Table 5.6. In order to appreciate the impact of the covariate, effect sizes (proportion of variance explained for) have been reported in the Table, in addition to (the usual) F ratios. The main effect of culture was substantially reduced by the covariate; after correction the multivariate effect was no longer significant ($p = .15$). The effect sizes reduced from .24 to .04 for digits, from .09 to .00 for short words, and from .07 to .01 for long words. The influence of reading speed on age differences was also sizable, although the multivariate effect remained significant after correction ($p < .01$). The effect sizes were reduced from .12 to .05 for digits, from .03 to .00 for short words, and from .14 to .08 for long words.

A different pattern emerged for gender differences. The effects sizes went up from .07 to .10 for digits, from .01 to .05 for short words, and from .00 to .01 for long words (the first two effect sizes are significant, $p < .05$, while the third one is not). It appears that gender differences are not reduced by correction for reading speed. The reason can be derived from an inspection of the mean scores of girls and boys on the dependent variables and the covariate. Whereas girls tended to score somewhat better on memory span (the difference just failed to reach significance), reading speed differences showed an opposite pattern: boys showed a higher performance. As a consequence, gender differences in memory span could definitely not be accounted for by differences in reading speed. Interaction components remained unimportant after correction for reading speed, as could be expected.

5.6 Discussion

The study was conducted to explore factors underlying memory span. The variables under investigation were age, gender, and culture. A number of statistical analysis were carried out to test the hypothesis of memory span and reading speed differences as related to the above mentioned variables. The first analysis was carried out on the Libyan data, where memory span was evaluated on four measures. The interest in this analysis was mainly to test the hypothesis of word length effect using short and long digits, and short and long words.

Table 5.6 Analysis of Covariance of Memory Span with Reading Speed as Covariate, as well as Effect Sizes before and after Correction for the Covariate

Source	Variable	*F*	*df*	*p*	η^2 before	η^2 after
				Multivariate tests		
Culture		1.83	3, 91	.15	.24	.06
Age		4.34	3, 91	.01**	.18	.13
Gender		4.17	3, 91	.01**	.07	.12
Culture x Age		3.96	3, 91	.62	.01	.13
Culture x Gender		0.40	3, 91	.75	.01	.12
Age x Gender		0.06	3, 91	.98	.00	.00
Culture x Age x Gender		1.40	3, 91	.25	.05	.04
				Univariate tests		
Culture	Short digits	3.94	1, 93	.05*	.24	.04
	Short words	0.08	1, 93	.78	.09	.00
	Long words	0.70	1, 93	.41	.07	.01
Age	Short digits	4.50	1, 93	.04*	.12	.05
	Short words	0.02	1, 93	.90	.03	.00
	Long words	8.14	1, 93	.01**	.14	.08
Gender	Short digits	10.49	1, 93	.00***	.07	.10
	Short words	4.87	1, 93	.03*	.01	.05
	Long words	1.00	1, 93	.32	.00	.01
Culture x Age	Short digits	1.42	1, 93	.24	.01	.02
	Short words	0.87	1, 93	.45	.00	.01
	Long words	1.20	1, 93	.28	.01	.01
Culture x Gender	Short digits	0.08	1, 93	.78	.00	.00
	Short words	0.20	1, 93	.66	.00	.00
	Long words	0.26	1, 93	.60	.01	.00
Age x Gender	Short digits	0.05	1, 93	.05*	.00	.00
	Short words	0.09	1, 93	.77	.00	.00
	Long words	0.00	1, 93	.99	.00	.00
Culture x Age x Gender	Short digits	2.90	1, 93	.09	.03	.03
	Short words	0.13	1, 93	.72	.00	.00
	Long words	0.08	1, 93	.80	.00	.00

$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

The results of the Libyan data confirmed the most consistent feature of the development of memory span; the developmental increase in span between the ages of 8 and 10 follows a similar pattern to that found in previous investigations (Hitch & Halliday, 1983; Hulme et al., 1984; Nicolson, 1981). There was a clear increase in memory span across the two age groups included in the study. The evidence suggests that span differences between children at the ages of 8 and 10 years could result from the use of rehearsal in the phonological loop, although the rehearsal hypothesis has been questioned as a general explanation for span improvement with age (Dempster, 1981).

The gender differences in memory span that we found are inconsistent with the idea that sex should not play a role in memory span differences. Only tentative explanations can be offered, for example, that the Libyan girls' higher performance on span measures, may be due to high motivation.

In effects of word length, two major variables are confounded, namely a word's speech time and the number of syllables it contains. Research results suggest that duration of an item is a powerful determinant of memory span, also termed 'memory capacity time.' The present study provides clear evidence supporting word length effect. A significant difference was found between recall of short words and long words. The effect of word length can be explained by the greater articulation time needed to pronounce long words in the phonological store (Broadbent, 1984; Hitch, Halliday, Schaafstal, & Heffernan, 1991; Hulme, Silvester, Smith, & Muir, 1986). Studies investigating the effect of word length on memory span have reported poorer performance in a memory span task when longer words are used (Baddeley et al., 1975).

The analysis of the combined data (scores on three span tasks of Dutch and Libyan children) revealed the same pattern of results with respect to working memory capacity. In particular, the limits of performance in the span tasks are consistent with a limited working memory. There was an age difference in all memory span tasks in the study. This is a clear indication of a systematic increase in memory span with age and further confirms previous reports on immediate serial recall performance. Cross-cultural differences in memory span were present in the three span tasks. The most plausible explanation is in terms of language differences in word length, including number words. Word length is likely to affect articulation rate, regardless of whether or not overt vocalization is involved (Ayres, 1984; Haber & Haber, 1982).

Results on reading speed of short-digit words, short words and long words indicated age differences in reading speed. Young children tend to articulate words more slowly than old children and that probably impeded their memory span. Age differences in reading speed are consistent with age variation in memory span, reflecting a common trend in span developmental increase with age. Dutch children were faster than Libyan children in speed of reading. The suggestion can be made that words in Arabic tend to have longer vowel sounds and take longer to pronounce than in Dutch. This may confirm results obtained by Naveh-Benjamin and Ayres (1986) for different languages on the time it takes to articulate the digits. Differences between languages in mean word length tend to be inversely related to reading speed and to memory span. This indicates that word-length effects reported for differences within a language (Baddeley et al., 1975) apply to differences between languages as well.

Memory span for words was lower than that for digits. Because digits can be pronounced more rapidly than words (Landauer, 1962), rehearsal explanation can account for such findings. However, rehearsal cannot explain the whole pattern of findings. Baddeley has argued that memory span is the number of information units that can be processed in two seconds. The present data indicate that this rehearsal rate varies both across stimulus length (short vs. long) and modality (digits vs. words). Whereas the short digit span is systematically overestimated by the reading speed for short digits, all other short-term memory span scores were systematically underestimated. Moreover, the difference in memory span for short and long stimuli is smaller than would be expected on the basis of the speed reading scores.

Although there is a convincing relationship between memory span and reading speed, correlational evidence is not a causal test of the hypothesis that speech rate determines memory span. Our study shows that Baddeley's articulatory model can successfully account for cross-cultural differences in the short-term memory span of Libyan and Dutch children. According to Poortinga and Van de Vijver (1987) cross-cultural psychology should attempt to model cross-cultural differences in behavior by referring to specific variables, like in the present case reading speed. On the other hand, Baddeley's model could only partly explain differences in performance across age, gender, and stimulus modes. It can be concluded that the model does not meet strong claims that it can explain all differences.

5.7 Summary

Forty Dutch subjects and sixty-four Libyan children at ages eight and ten were recruited. Subjects were tested on memory span for digits and words as well as on reading speed for the same tasks. Libyan subjects were exposed to four subtests for memory span and four subtests for reading speed. The analyses of the Libyan data showed significant differences for age and gender, and indicated a word length effect for memory span. Dutch data followed much the same pattern as those of the Libyan subjects. Causal modeling indicated that reading speed is related to memory span; reading speed explained part but not all of the variance in memory span. With analysis of covariance we could provide support for the articulation model, as far as cross-cultural differences is concerned. Age differences could be partly explained, but gender differences in memory span could not be explained in terms of reading speed.

Chapter 6

Study 2 Memory Span and Rehearsal Training

6.1 Introduction

A great deal of research in memory development has demonstrated that age-related changes in memory performance are linked to the growing child's more frequent, spontaneous, and flexible use of mnemonic strategies (cf. Brown et al., 1983; Hagen, Jongeward, & Kail, 1975). A shift in theoretical conceptualization of memory stimulated new efforts in experimental psychology to analyze the magnitude and sources of individual performance differences. While psychometricians were mainly interested in differences at performance level, cognitive psychologists were concerned with the identification of underlying psychological mechanisms and processes. Especially short-term memory processes became a fashionable and productive area of study (Cohen, 1982; Kirby, 1980).

One question in the literature has been to identify memory processes that are causing interindividual variance as well as developmental differences in memory span tasks. According to Dempster (1981), there is no conclusive evidence that any of the strategic memory processes (e.g., chunking, rehearsal, and grouping) or the overall capacity of the system plays a role in interindividual memory span variance. The studies reviewed by Dempster suggest that the important factors underlying span differences are non-strategic ones. Especially, the speed with which stimuli can be identified has proved a major source of both individual as well as developmental differences in memory span.

In another line of research the hypothesis was tested that interindividual differences in memory may reflect a general strategy factor. Some individuals may use memory strategies consistently and perform well, whereas others may use memory strategies poorly and thus remember inaccurately. For example, in a study by Kail (1979) third- and sixth-graders were tested on three memory tasks. From each task, a strategy-free and a strategy-based measure were derived. The results of factor analysis confirmed the hypothesis, at least for the sixth graders; all three strategy-based measures loaded heavily on one factor. For the third-graders, no such factor could be detected.

The most convincing evidence in favor of a general strategy factor and consistently high intertask correlations stems from a study by Cavanaugh and Borkowski (1980). They tested kindergarten children, first, third, and fifth graders, using three different memory tasks (i.e., cognitive cueing, free sort, and alphabet search), and assessed the degree of consistency across the three tasks by computing intercorrelations among measures of study strategy, recall, and clustering during recall. A significant developmental improvement was found for almost all intercorrelations. Such investigations have led to the generally accepted view that better memory performance from about age six on is largely due to the older child's increasing propensity to employ deliberate memory strategy to aid both storage and retrieval.

The developmental course of a number of different strategies such as rehearsal (Ornstein & Naus, 1978), organization (Ornstein & Corsale, 1979), and elaborate procedures, both verbal and visual (e.g., Levin, 1983; Pressley, 1982;) has been carefully charted. Considerable research has been conducted with normal children of school age; in addition, numerous investigations were carried out with special populations, particularly mentally retarded and learning disabled children (e.g., Belmont & Butterfield, 1977; Borkowski & Büchel, 1983; Borkowski & Cavanaugh, 1979; Campione & Brown, 1977). Much effort has been directed towards the development of training procedures that foster the memory performance of inefficient learners. The literature suggests a transition from relatively passive to more active techniques of memorization. For example, in free recall tasks (e.g., Ornstein et al., 1975), children in the early elementary school years tend to rehearse each to-be-remembered item as it is presented, whereas older subjects rehearse each item with several previously presented stimuli. These differences in rehearsal style are clearly related to corresponding differences in recall success. Corresponding findings have been obtained in studies of children's organizational techniques (see Chapter 2 of this report).

With both rehearsal and organizational strategies, training studies have been employed to demonstrate direct links between strategy utilization and recall. For example, instructions to younger children to rehearse more actively have been shown to improve their recall (Naus et al., 1977; Ornstein et al., 1977). Furthermore, the dependence of memory strategies on the stimulus properties of the to-be-remembered material was demonstrated in various studies; for example, Tarkin (1981) found that third graders' rehearsal differed with meaningfulness of words. Less meaningful items were less frequently rehearsed and less frequently recalled.

6.2 Rehearsal Training

The literature on rehearsal was reviewed in Chapter 2. Here we elaborate on some points relevant to the training of rehearsal. There is a progressive developmental increase in memory span. The major hypothesis which has been proposed to account for the increase in span is the emergence of active strategies during childhood (Bebko, 1979; Flavell et al., 1966; Guttentag et al., 1987). With age, children learn to rehearse, and this causes the developmental increase in memory span. Other investigators have found that memory span is correlated with speech rate (cf. Baddeley et al., 1975; Hulme et al., 1984; Hulme & Tordoff, 1989; see also Chapter 5 of this report). These correlations presumably occur because subjects who can speak more quickly can engage in more efficient rehearsal strategies.

Memory research examined the contribution of rehearsal to memory performance with children as well as adults. Children use verbal rehearsal more as they increase in age (Flavell et al., 1966) and rehearsal techniques become more cumulative throughout the elementary school years (Naus et al., 1977). Flavell and his colleagues showed that the likelihood of a subject spontaneously rehearsing increased sharply between kindergarten and fifth grade. Almost none of the kindergarten children were observed to rehearse. Analyses of children's rehearsal indicate clear developmental changes in both the probability of spontaneously rehearsal, and in the patterns of rehearsal. For example, with an overt rehearsal procedure, Ornstein et al. (1975) have found that third graders rehearse each item as it is presented either singly or in minimal combination with other items. In contrast, sixth graders (and older subjects) rehearse more actively, with several items being combined. An implication of these findings is that the content of rehearsal may be a critical determinant of recall. Ornstein et al.'s (1975) data indicate that rehearsal content is a more important determinant of recall than rehearsal frequency.

According to the dual store model of memory (e.g., Atkinson & Shiffrin, 1968), these developmental changes in recall represent differences in information transfer to or from long-term store. The equivalence in recall of the final items suggests that age-related differences in recall from short-term store are slight. Alternatively, from a levels-of-processing point of view (Craik, 1973; Craik & Lockart, 1972), these age changes in recall would be seen as representing differences in the extent to which initial list items are processed. Given either of these theoretical positions, rehearsal factors may underlie developmental changes in recall.

Using a short-term task, Kingsley and Hagen (1969) observed an increased primacy effect when cumulative rehearsal instructions were given to first grade children in a cued recall task. Keeny, Canizzo, and Flavell (1967) gave rehearsal instructions (to whisper words aloud), to first grade subjects who did not rehearse spontaneously. They found that training children to rehearse picture names during a forced delay mode, can make recall of children who did not rehearse spontaneously rehearse as good as that of spontaneous rehearsers. In the experiment they tested only one age group. Another training study, by Bebko (1979) was described in the previous chapter. Bebko concluded that children who make use of rehearsal have a general encoding advantage. Like in most other studies mentioned in this section, Bebko did not test the age hypothesis. The method of rehearsal training used by Bebko was also open to question. Henry (1991) commented that children had to repeat each new item as it was presented, followed by a recall of prior items in order; the children were corrected for errors. This was, therefore, list learning over trials rather than rehearsal as generally understood.

As mentioned, investigators concerned with the development of serial recall have suggested a close relationship between increases in speech rate and improvement in memory on serial recall tasks. A way to test this is to train children to increase their speech rate. For example, Hulme and Muir (1985) trained children aged seven years to increase their speech rate, in order to test whether this would increase their recall; they immediately tested serial recall after training. The results indicated a very small increase in speech rate and recall and the study was not conclusive. In a subsequent experiment, Hulme and Muir gave children an extensive training over five consecutive days. Data from the previously trained group and the extensively trained groups were compared. There was no overall difference in recall between the two groups. The extensive training of speech rate did not produce any selective increase in recall scores. However, there are also studies that have shown positive results and the idea of a causal link between the training of speech rate and serial recall continues to find acceptance. For example, Henry and Millar (1991) gave children aged 5 and 7 years words to recall for which they had the same speech rate. In this way they succeeded in getting equal memory span of the two age groups.

Attempts to increase memory span through training have encountered important difficulties. This can be illustrated with a study by Cowan, Saults, Winterowd and Sherk (1991). They trained 4- and 5-year-old children to rehearse cumulatively a spoken list. Subjects were to repeat the entire list after the presentation of each item. They were moderately successful in training children to carry out this task, but cumulative rehearsal did not raise performance above the level obtained in an ordinary span task. Cowan et al. (1991) suspected that the attention demands of carrying out cumulative rehearsal at these young ages were so great, that subjects were distracted from the primary task of memorization. It seems likely that there are age-related changes in some fundamental information processing skills that influence the efficiency with which active memory strategies can be utilized. With increases in age –or with the provision of appropriate support to younger children when these are lacking– the application of mnemonic strategies seems to require less effort and to become increasingly routinized. Thus, with increases in age, children become more effective in strategy use. Ornstein et al. (1985) indicate that when the retrieval demands of the task are minimized, second graders can execute an active rehearsal strategy quite effectively. In this experiment, second graders rehearsed aloud under a variety of different rehearsal conditions. The number of items varied in each rehearsal set. Compared with a baseline condition, the children benefited from an instruction to actively rehearse the items. However, the effectiveness of the instruction was enhanced markedly when the subjects were given additional processing time. The results indicated that recall was facilitated by the children's more efficient deployment of the rehearsal strategy. These results suggest that children in the early elementary school years may be aware of the importance of active mnemonic techniques, but less skilled than older children in using some of the component processes involved in implementing effective strategies.

Despite strong interest in memory span development, factors in the child's environment that contribute to changes in memory span and reading speed have received little research attention. There is little information concerning the manner in which children are instructed in memory strategies in their day-to-day activities. Moreover, almost all investigations on rehearsal training were conducted by using Western subjects. The absence of cross-cultural training studies in rehearsal is remarkable (Van de Vijver, Daal, & Van Zonneveld, 1986).

6.3 Hypotheses

The main question addressed in the present study is whether training children to implement certain rehearsal strategies can improve their memory span and enables them to use such strategies more effectively. Furthermore, it was considered to be of interest to address this issue cross-culturally. To investigate this Libyan and Dutch children were given a training to implement rehearsal strategies in a memory span task. The question raised then is whether training on rehearsal strategy, would assist in serial recall and increase the magnitude of verbal memory span of children in Libya and the Netherlands.

The following specific hypotheses were tested:
(*H1*) There is a positive effect of rehearsal training.
(*H2*) Older children gain more from training than younger children.
(*H3*) Training has an equal, positive effect in both cultural groups.

6.4 Method

6.4.1 Subjects

In the two countries, The Netherlands and Libya, pupils from primary schools participated in the study. In the Netherlands children enroll in primary school at age six, while in Libya children are at seven years of age when they start primary school. The Dutch sample consists of 68 six- and eight-year-old children from the first and third grades. The subjects were chosen from three elementary schools located in villages close to the city of Tilburg.. The Dutch children mainly came from middle class families. The Libyan sample consists of 64 subjects representing two age groups (eight and ten years old). The subjects were chosen from second and fourth grades in elementary schools located in villages close to the small city of Garian in the Western part of Libya. The children mainly came from middle class families. The age of the younger group was determined in a pilot study; it was the minimal age at which the memory task could be adequately administered.

In both samples half of the subjects were girls and the other half were boys; equal numbers of younger and older children were selected. Children in each cultural group were assigned randomly to the non-training (control) condition and the training (experimental) condition. The age groups were chosen because they represent the age range for which, among others, Flavell et al. (1966) and Kingsley and Hagen (1969) have noted an increase in spontaneous use of rehearsal.

6.4.2 Materials and Procedures

There were two sets of Dutch words, and two sets of Arabic words for pretest and posttest. Each set was drawn from a large pool of words highly familiar to the children. One set consisted of fruit names and the other of animal names. Lists of stimuli were constructed with the words. The number of words ranged from three to seven words with three lists at each level. Words were not repeated in the same trial, and words at the end of a previous trial were not repeated at the beginning of the next trial, to prevent systematic patterns from entering the lists. Practice lists to be used in the training phase were separately derived which did not overlap either with the pretest or the posttest lists.

For training purposes four sets of unrelated word names were selected from current Dutch first and third grade elementary school textbooks. Corresponding sets of Arabic words were chosen from the Libyan primary school textbooks. In this way we assured that the words would be familiar to the subjects. It may be noted that the Dutch and

Libyan stimuli were chosen independently and were not translations of each other. Each set of stimulus material was developed and arranged in lists separately.

Procedure The design of the study was based on two age groups of Libyan children (8 and 10 years), and Dutch subjects (6 and 8 years), two experimental conditions (rehearsal training group and untrained group), and two testing sessions (pretest, posttest after training). The study involved three phases: (1) a pretest to determine the initial span; (2) training (or no training, as appropriate); (3) a posttest to determine span after training. The same lists of words were used for the pretest and posttest. Half the subjects received the fruit words test first, then the animal words test; the other half had the opposite order.

The *pretest* was a typical test of memory span. After familiarizing the subject with the words and some practice trials items were presented at the rate of one item every two seconds. This slow presentation rate was necessary to allow the child to rehearse. Children were neither prevented nor encouraged to use any strategy, but it was expected that older subjects would more rehearse spontaneously. Span testing was progressive, starting with three items per list and with three trials at each list length. The subject was required to repeat correctly two out of three trials in a correct serial order at any list length. An extra credit of 0.5 was given if one trial at the next list length was recalled correctly. The span score was recorded for each subject.

For the rehearsal training lists of unrelated words were used. During the course of training, each child was seen individually over a total of three days/sessions. The training period lasted approximately 15 minutes for each subject. The training was to teach the subject to recite, quickly, groups of words during the standard presentation of lists and before recall. The training was started on the list length that the subject had failed in the pretest of memory span. A list was divided into groups of words (2 and 1, 2 and 2, 3 and 2, depending on the span level that might have been obtained by a child on the pretest). The child listened to the first two or three words, and then quickly repeated them together overtly. Then he or she listened to the next one, two or three words and then said them quickly and overtly. Then the child said all the words together. The experimenter demonstrated this on different trials. Practice trials followed until the subject completed two trials correctly in any consecutive three, using the training rehearsal strategy. Extensive prompting was provided to use the strategy, and instructions were repeated before every trial. The child was encouraged to participate actively and to ask questions, to ensure that he or she understood and remembered the procedure.

The control group did not receive any instructions on how to remember or to rehearse the items. The subjects were told that they were going to practice remembering the words. They were only told to repeat the items of the list, with no instructions of any rehearsal strategy. The practice trials were on the span length that the subject has failed on the pretest.

The *posttest* was a replication of the pretest. The procedure was the same as in the pretest, except that the subjects in the rehearsal condition were reminded to apply the rehearsal strategy before each trial. If a rehearsal subject succeeded on the list length that he/she had been trained on, the rehearsal instructions which had been given as prompting before the successful trial were adapted to a new grouping. For example, a subject who had been trained on a list length of four, rehearsed the items in groups of two. If the subject went on to five, then he/she was told that the next time the grouping would have to be three and two ('listen to the first three words and say them quickly to yourself, and then listen to the next two words (as before) and say them quickly to yourself and say them all together').

6.5 Results

An analysis of variance with repeated measures was carried out to test the effects of the experimental treatment (rehearsal vs. non-rehearsal), grade (first/second vs. third/fourth grade) and culture (Libyan vs. Dutch). The dependent variable was the memory span of the children. The analysis (see Table 6.1) showed a significant effect for training ($F(1, 124) = 4.69$, $p < .05$), although the proportion of systematic score variance explained by training (η^2) was a modest .04. The average mean score of the experimental group was 4.32, while the mean score of the control (non-trained) group was 4.14. This finding confirmed the first hypothesis that subjects gain from training (another hypothesis test is described below). The main effect of grade level was also significant, $F(1, 124) = 18.23$, $p < .001$, explaining .13 of the total score variance. Higher-grade subjects remembered more than did lower-grade subjects; the mean scores were 4.41 and 4.06, respectively. This finding is in line with the main tenet of the developmental memory literature in which older children are reported to show a higher performance. In addition, the main effect of culture was significant, $F(1, 124) = 16.84$, $p < .001$ (explaining 12% of the variance). The mean score of the Libyan children was 4.40, which was higher than the mean of 4.06 of the Dutch subjects. There was a significant interaction effect between culture and experimental treatment, $F(1, 124) = 4.32$, $p < .05$, $\eta^2 = .03$. Differences between the experimental and control groups in the Libyan sample were larger than those in the Dutch group (see Table 6.2). The difference between the experimental and control group was 0.35 in Libya and merely 0.12 in the Netherlands. Furthermore, there was a significant interaction effect of age and culture, $F(1, 124) = 4.20$, $p < .05$, $\eta^2 = .03$. The score increase from the lower to the higher grade was larger for Libyan children than for Dutch children (0.52 and 0.18, respectively).

The analysis showed a significant main effect of time, $F(1, 124) = 175.92$, $p < .001$. The mean score of the posttest was 4.50, which was larger than that on the pretest 3.95; this pretest—posttest difference was by far the largest source of score variation and explained 59%. This finding supported the third hypothesis that rehearsal training has an equal, positive effect on short-term memory. A significant interaction effect was found between time and experimental treatment, $F(1, 124) = 28.44$, $p < .001$; the interaction explained 19%, which is higher than the value obtained by any between-subjects effect.

Table 6.1 Analysis of Variance of Training, Grade and Culture on Memory Span Performance (η^2 Refers to the Proportion of Variance Explained)

Source of variation	*df*	*MS*	*F*	η^2
Within Residual	124	0.45		
Training (T)	1	2.14	4.69*	.04
Grade (G)	1	8.25	18.23***	.13
Culture (C)	1	7.62	16.84***	.12
T x G	1	0.29	0.64	.01
T x C	1	1.95	4.32*	.03
G x C	1	1.95	4.20*	.03
T x G x C	1	0.23	0.50	.00
Within Residual	1	0.11		
Time (Ti)	1	19.80	175.92***	.59
T x Ti	1	3.20	28.44***	.19
G x Ti	1	0.07	0.65	.01
C x Ti	1	0.47	4.21*	.03
T x G x Ti	1	0.02	0.20	.00
T x C x Ti	1	0.03	0.28	.00
G x C x Ti	1	0.65	5.80*	.04
T x G x C x Ti	1	1.22	10.80***	.08

*p < .05. **p < .01. ***p < .001.

The posttest gain of the experimental groups was on average 0.77, while the gain was 0.33 for the control group. In other words, the control showed somewhat higher scores at the posttest (possibly due to training effects), but the experimental groups showed a much larger increase, indicating that the training enlarged the short-term memory span of both Libyan and Dutch children. This significant interaction provided another conformation of the first hypothesis.

The analysis indicated a significant interaction effect of culture and time, $F(1, 124) = 4.21$, $p < .05$, $\eta^2 = .03$. The pretest-posttest differences were larger in the Libyan group (0.63) than in the Dutch group (0.46). A significant triple interaction effect was found between grade level, culture and pretest-posttest scores, $F(1, 124) = 5.80$, $p < .05$, $\eta^2 = .04$. A close inspection of Table 6.2 shows that the effect is mainly due to the relatively large gain from the pretest to the posttest in the older group of the Libyan children.

Table 6.2 Means of Rehearsal Training for Treatment, Grade, and Culture

		Grade 1, 2			Grade 3, 4		
Culture		Exp.	Contr.	*Average*	Exp.	Contr.	*Average*
Libyan	Pretest	4.00	3.78	*3.89*	4.28	4.28	*4.28*
	Posttest	4.63	4.16	*4.40*	5.41	4.69	*5.05*
	Average	*4.32*	*3.97*	*4.14*	*4.85*	*4.49*	*4.67*
	Gain	*0.63*	*0.38*	*0.51*	*1.13*	*0.41*	*0.77*
Dutch	Pretest	3.47	3.94	3.71	4.00	3.91	4.12
	Posttest	4.35	4.12	4.24	4.44	4.26	4.69
	Average	*3.91*	*4.03*	*3.98*	*4.22*	*4.09*	*4.41*
	Gain	*0.88*	*0.18*	*0.53*	*0.44*	*0.35*	*0.57*

Finally, the interaction of treatment, grade, culture, and time was found to be significant, $F(1, 124) = 10.80$, $p < .001$, $\eta^2 = .08$. Differences in pretest-posttest changes between experimental and control subjects were smaller in the lower grade in Libya than in The Netherlands while the opposite was found for the higher grade.

The second hypothesis specified that older children would gain more from training than younger children would. The hypothesis could not be tested in the previous analysis, as it does not involve the control group. Therefore, a *t* test was carried out per country on the differences of the posttest and pretest means of the (experimental) younger and older children. The Libyan data confirmed the hypothesis. The gain was 0.63 in the younger group and 1.13 in the older group, $t(30) = -2.66$, $p < .01$ (one-tailed). The Dutch data did not support the hypothesis. The gain was 0.88 in the younger group and 0.44 in the older group, $t(32) = 2.22$. If this difference would be tested two-tailed, this *t* value is significant, but in the other direction than predicted by the hypothesis. In sum, the Libyan data support the hypothesis, but the opposite pattern was found for the Dutch subjects.

6.6 Discussion

The results from this study confirmed previous work indicating that children often can profit from instructions to approach a memory task with a certain strategy. The results showed that rehearsal training was effective in improving memory span of the younger and older children in both countries providing support for the first hypothesis that rehearsal techniques can be modified by relatively simple training procedures. At both grade levels the use of active rehearsal techniques in which several items are rehearsed together resulted in a larger gain in performance for the experimental group.

Training was more effective with the older children in Libya and with the younger children in the Netherlands. The larger increase in the performance of the experimental groups in the Libyan sample compared to the Dutch subjects may have to do with age differences between the two samples. The Dutch children were almost two years younger than the Libyan children. Another explanation of this difference is that most of the Libyan children attend Quranic summer schools where they have the opportunity to practice some kind of cumulative rehearsal similar to that implemented in the study. This may also explain why Libyan control children tended to show larger score gains at the posttest than their Dutch counterparts. This explanation is consistent with Scribner and Cole's hypothesis that there are effects of Quranic schooling on serial memory (Scribner & Cole, 1981; cf. also Wagner & Spratt, 1987).

This study provides empirical evidence for the argument that differences in performance on memory span of children are likely due for a large part, to differences in level of practice of memory skills. It may be remarked that the study yielded some support for the idea of a linear relationship between rehearsal training and memory span improvement with younger children. However, simple mental exercise does not improve memory. It may take quite some more training for the younger children to improve fully to the level of skill development of the older subjects. Training is important to produce strategy use, but the effectiveness of strategy training may depend in large part on motivational factors, interests, and self-control training together or in isolation. Those variables might be included in future research.

6.7 Summary

Sixty-eight Dutch subjects aged six and eight years and 64 Libyan children at the age of eight and ten years were randomly assigned to rehearsal training and no-training groups. In the rehearsal training condition, subjects were trained to recite quickly groups of words during presentation and before recall. Subjects in the control group were exposed to the practice items. Subjects were pretested to assess their initial span. The posttest was a replication of the pretest. The results indicated a significant score increment after training which was much larger than the score increment of the control group. Age was also significant, older subjects scored higher than younger subjects. The main effect of culture was significant, Libyan subjects scored slightly higher than Dutch subjects. Differences between experimental and control groups of the Libyans were larger than those of the Dutch. The interaction of age and culture was significant; the difference between older and younger Libyan subjects was greater than that between the Dutch subjects. The hypothesis stating that older children would gain more from training than younger children would was confirmed in Libya while the opposite pattern was found in the Netherlands.

Chapter 7

Metamemory Development of Libyan and Dutch Children

7.1 Introduction

In the last few decades a marked change has occurred in the way psychologists look at memory. This has provoked new thinking on the development of memory in children. The new perspective to study memory has led researchers to investigate memory strategies that might lead to better remembering. The ability to remember is an internal mental process that must be learned and discovered by every child. Knowledge of one's memory has been termed 'metamemory.' The present study is aimed at the exploration of some aspects of metamemory of children in the middle grades of primary school in a cross-cultural context. The study was conducted in Libya and the Netherlands.

Metamemory researchers have developed different ways to assess metamemory. Most metamemory measures consist of interviews and questionnaires about memory processes. Most of the literature on metacognition was reviewed in Chapter 3. Here we emphasize some issues of method that indicate why it has been difficult to accumulate a coherent picture of the metamemorial functioning of children.

Kreutzer et al. (1975) developed one of the earliest batteries to assess metamemory behavior of children in kindergarten as well as first, third, and fifth grades. They used an interview technique to assess children's knowledge about everyday memory phenomena such as planning for future events (e.g., remembering to bring ice skates to school the next day) and recalling past events (e.g., remembering how long one has a dog). Knowledge about person variables was assessed by asking questions about personal characteristics (e.g., Can you remember better than your friends or do they remember better than you?), strategies (e.g., While you are in school, you lost your jacket. How can you find it? What you can do to find it?), and task demands (e.g., these two sets of pictures are similar, the only difference is that one set is in color, and the other is black and white. Tell me which set would be easier for you to learn?). Kreutzer et al. indicated that even a child in kindergarten has developed an understanding of mental processes and knows that memory performance is affected by familiarity of items and study time.

Subsequent research in metamemory development has incorporated some of the items of Kreutzer et al.'s (1975) questionnaire, with attempts to assess the validity and reliability of items (e.g., Belmont & Borkowski 1988; Cavanaugh & Borkowski 1980; Kurtz et al., 1982). According to Kurtz et al., (1982) most of the data obtained were consistent with Kreutzer et al.'s (1975) original findings.

Levin, Yussen, DeRose, and Pressley (1977) developed a procedure in which children are asked to estimate the number of items they can remember on a memory task; next a list of items to-be-remembered is administered and the children are informed about their correct recall; finally they are asked to estimate their recall on a similar task. Children in the middle grades of primary school readily adjust their estimate according to their real recall on the first task, while six-year olds report unrealistically high expectations for future recall despite feedback about their actual performance. Other studies were carried out, for example, by Brown (1978), Cavanaugh and Perlmutter (1982) and Hasselhorn (1995).

Metamemory has also been assessed through the use of illustration techniques. Wellman (1977) and Yussen and Bird (1979) developed procedures in which pictures portrayed characters in different memory-related tasks. For instance one picture shows a girl trying to learn the names of five people and another picture present a girl trying to learn the names of 15 persons. The task was to answer questions about memory by selecting one of the two pictures. Justice (1985) obtained good results through the use of videotapes. Children were watching another child using various memory strategies (looking, naming, rehearsing, and grouping), and the children were asked to choose the strategy more useful in different memory tasks.

In another assessment procedure, based on peer tutoring, Best and Ornstein (1986) taught a memory strategy to a target child who was asked to teach the strategy to another child. The first child's instructions to his peers were analyzed to provide a measure of metamemory.

In general the methods discussed showed a rather moderate overall relationship between metamemory and memory behavior (Schneider, 1985; Schneider & Pressley, 1997). But they all have problems, some of which are very serious. The difficulties in metamemory assessment are associated with the particular approach being adopted in a technique. The most serious problem in metamemory evaluation has been the reliance on self-report (e.g., Brown et al., 1983; Schneider & Pressley 1989). Metamemory is cognitive in nature, and like all mental processes it cannot easily be measured through direct observation. Instead, individuals are usually asked questions about memory processes using a verbal report. Verbal reports are subject to many of the criticisms of other interview data. Differences in verbal skills can bias interpretations of developmental differences obtained using such methods in assessing metamemory. In addition, there are serious problems in asking children to comment on hypothetical situations that they may have never experienced or may have little knowledge about. Moreover, interviews usually involve subjects verbalizing about general cognitive processes rather than task-specific ones, which may limit the chances of being true reflections of the subjects' knowledge.

The techniques of Wellman (1977, 1978) and Yussen and Bird (1979) in which children are presented with pictures of actors engaged in various memory tasks and asked to rank order the effects of, among other things, age, time, and hair color by selecting pictures, are less dependent on expressive language skills. However, rank ordering procedures are subject to the criticism that administration complexity may be tiring for younger children regardless of the content of the questions.

The peer tutoring procedures used by Best and Ornstein (1986), although they seem more adequate in motivating young children, suffer from the constraint that peer tutors may not be able to express all the needed questions in the experiment simply because they forget what they have to ask or explain.

Problems associated with the prediction by children of their own memory capacity follow from the fact that young children notoriously overestimate their capacities and often respond inconsistently. Moreover, span estimations, whether they are accurate or not, seem to vary with material and familiarity, and whether or not children received training on the task (Cunningham & Weaver, 1989; Markman, 1973). It has been found that the modality of presentation affects the accuracy of estimation of young children. For example, Cunningham and Weaver (1989) found that preschoolers' span predictions were more realistic in a listening task when they used a stop key to indicate the list was getting too long rather than when they responded to verbal prompts

A practical difficulty is that the above mentioned procedures of assessment often are based on time-consuming individual testing that, in addition, may not be highly valid. To alleviate some of these problems, Belmont and Borkowski (1988) designed a group-administered metamemory test battery that has been widely used and yields a broad picture of children's memory knowledge. Initial support for the validity of the test was provided by age-related performance differences for each of the subtests (Belmont & Borkowski 1988). These findings are encouraging for further studies aimed at providing empirical support for group-administered metamemory testing in applied settings.

The present study addresses two aspects of metamemory development and the assessment of metamemory. First, there is a considerable amount of literature on metamemory development. Much of this work has been conducted in Western countries. Only few studies were carried out cross-culturally. By including Dutch and Libyan children our study extends over two culturally quite different groups. Second, it is evident that the results from studies of metamemory and metamemory—memory relationships are rather mixed (Schneider, 1985; Schneider et al., 1987). One possible explanation for the inconsistencies is that metamemory should be conceived of as a multidimensional construct, and that perhaps only certain dimensions of knowledge and beliefs about memory are relevant for specific memory tasks. By administering a multidimensional instrument representing selected facets of the content domain of metamemory a broader picture can be obtained. For purposes of validation the scores on the various tests of metamemory were correlated with the children's achievement at school.

7.2 Method

7.2.1 Subjects

The Libyan sample consisted of 80 primary school subjects; 40 subjects were chosen from the third grade and 40 children were recruited from the fifth grade. Half of each group were boys and the other half girls. The Libyan sample was randomly chosen from two primary schools in a semi-urban area of Garian that is located in the Western part of Libya. All the Libyan subjects came from middle-class families. The Dutch sample consisted of 82 subjects, 41 subjects were chosen from third grade, and 41 children were taken from the fifth grade. Half of each group were boys and the other half girls. The subjects were chosen from four schools situated in villages and small towns close to the city of Tilburg in the Netherlands. Most subjects came from middle-class families.

7.2.2 Instruments

The Metamemory Battery (MMB) developed by Belmont and Borkowski (1988) was adapted for the present study. The battery consists of four subtests, Memory Estimation (EST), Organized List (OL), Paired Associates (PA) and Preparation Objects. To increase the reliability of the test, items were added to the Memory Estimation, Paired Associate and Organized List subtests. Other alterations were made, to make the test more familiar to the Libyan children. For example, 'ice-skates' were substituted with 'sport shoes,' and all unfamiliar words were changed into more familiar words for both the Libyan and Dutch children. A pilot study was carried out for the Arabic version of the test with Libyan children. Changes were made in the sequence of the lists of the Memory Estimation (EST) subtest. The timing was changed in order to give more time to the children to understand the questions and to answer them.

The test was originally written in English; both Arabic and Dutch versions were prepared and combined into booklets with the same sequence of subtests. Administration instructions were written and a scoring manual was prepared.

In the *Memory Estimation Subtest (EST)* children are presented with a list of 10 words and asked to estimate how many words they would recall if given two minutes to study the list. Next the children see a list of 15 words and asked to write down how many words they would remember after two minutes study. Then the children see a list with 20 words and are asked if given two minutes to study the list how many words they could recall. Thereafter they are actually given two minutes to memorize each list and are tested for immediate recall. Subsequently they are asked to make another estimation about new lists of 10, 15, and 20 words, respectively. It is assumed that the intervening free-recall experience will inform the children about their real memory capacity. Therefore, scores are derived from a weighted combination of the first estimated recall and the number of words actually recalled as well as the second estimated recall and the number of words actually recalled.

The first three scores EST1a, EST1b, and EST1c, respectively indicate how many items the children estimate they can free-recall if given two minutes to study each list. Subsequently, they are asked to make an estimate (EST2a, EST2b and EST2c) about new lists of 10, 15, and 20 words. It is supposed that intervening free recall experience will inform the children so that EST2 will be closer than EST1 to their actual recall (RECALL). Therefore, EST2 is given more weight than EST1 (weights are four and five, respectively). Scoring begins by calculating the absolute difference between EST(1a) and RECALL(a) and between EST(2a) and RECALL(a). Each of these absolute differences is then divided by RECALL(a), to obtain the two proportional errors, each of which is then subtracted from 1. A negative result is scored as zero. Finally, the two scores are multiplied by their respective weights of 4 and 5 to yield the two weighted scores, which are then summed to yield the total weighted EST(a) score. The total test score is the sum of the scores on the three series (ESTa, ESTb, and ESTc). The maximum score is 27.

In the *Paired Associates subtest (PA)* the children see two pairs of words, one pair consists of high-association words (e.g., summer-beach) and the other pair consists of low-association words (e.g., dress-tree). Children are asked to study the pairs and decide which pair would be easier to learn. They are instructed to put a check mark in the little box in front of the pair to indicate their answer. The task requires an implicit understanding of the mnemonic use of associations between related words as contrasted to unrelated words. An implicit understanding of this association should influence the child's choice. Scoring was in a true-false format, where subjects have to choose one correct answer for each item that consists of two pairs of words. One point was assigned for each correct answer. There are 7 items; the maximum score is 7.

In *Organized List subtest (OL)* there are three lists of five words each. Two lists contain unrelated words, while the words in the other list are from a single category. The children were instructed to mark the list that would be easier to learn. It is assumed that a single category list is easier to learn, because clusterable words are easier to learn than non-clusterable words. Performance on this subtest is an indicator of the child's understanding that categorical organization facilitates learning.

There are four items, each consisting of three lists with five words. Two of the lists consist of unrelated words, while the words in the third list are from a single category. The score is obtained by counting the total number of correct choices (0-4) and multiplying this count by 3 (maximum score = 12).

The *Preparation Object subtest (PO)* consists of a single question. The subjects are asked to write down things they can do at night that will help them remember to bring their sport shoes/ice-skates to school the next morning. Seven main classes of strategies were identified that can be used by the subject. Within each class there are various ways of implementation (i.e., a subject may do something with the sport shoes, such as put them in a bag, wear them to bed, etc.). One point was given for each reminder indicated by the subject, adding up the points across the classes composes the subject's total score. Classes were considered unique methods and as independent strategies.

In their test booklet the subjects are given 7 lines on which to write down things they could do tonight that would help them remember to bring their sport shoes to school tomorrow. Scoring is based on not more than seven responses (the first that are given). Each response is assigned to a class, labeled a through g:

(a) External aid (passive); e.g., leave a note on the refrigerator, draw a picture;
(b) External aid (active); e.g., set my radio to play soccer match;
(c) External aid (item manipulation); e.g., put shoes by the door;
(d) External aid (other person); e.g., ask Mom to remind me;
(e) One's body as aid; e.g., tie a string on my finger;
(f) One's brain as aid; e.g., say 'remember the shoes' three times at bedtime;
(g) Seek other ways; e.g., ask Mom how I could remember.

One point is assigned for each different class used (max. = 7); one bonus point is assigned if more than three different classes are used (max. = 1); one bonus point is assigned for each different class that is used more than once (max. = 3). The scoring and bonus rules are not treated as independent. For example, the subjects who uses all seven classes receives seven points under (a), plus one bonus point under (b), but no bonus points under (c). This subject's score of 7 + 1 + 0 = 8 is the maximum possible. A subject who uses six different classes, but uses one of those twice, would also receive the maximum (6 + 1 + 1 = 8).

Test sessions were conducted in schools in small groups. The experimenter read the instruction to the children, who wrote their answers in the test booklet. Separate subtest scores were calculated as indicative of subject's task specific strategies. Finally, school achievement scores in mathematics and reading comprehension of both Libyan and Dutch groups were collected from the schools.

7.3 Results

7.3.1 Analyses per Country

Means and standard deviations of the subtest scores have been presented in Table 7.1. The means of all subtests are higher among the older children, with the exception of Strategy Generation in the Dutch group. It was found in $\underline{t}$ tests for independent samples that all these differences were significant (Bonferroni-corrected overall alpha of .05), with the exception of Strategy Generation in the Libyan group and Paired Associates in the Dutch group. In both cases the older children obtained higher scores, but the differences did not reach significance. The increase of scores with grade was 0.53 SD in the Libyan group (range: 0.41 to 0.67), which pointed to a relatively homogeneous development across the subtests. The pattern was less even in the Dutch group. It was not expected that the Strategy Generation subtest would show a significant decrease of 0.65 SD. in the Dutch group. The decrease was mainly due to the smaller number of responses given by the older Dutch children. When prompted, younger children are often inclined to generate more responses that belong to the same category (e.g., putting the shoes at various places in the house or asking both parents and siblings to remind then the next morning). This answer strategy leads to a higher score (bonus points), but older Dutch children probably did not find it obvious that variations on an earlier answer were allowed and indeed reinforced by the scoring rules.

The interrelations of the subtests also yielded some unexpected results (see Table 7.2). First of all, it is quite clear that the correlations are not identical for the two groups. For example, the Organized List and Paired Associate Subtests showed a positive and significant correlation of .26 ($p < .05$) in the Libyan group, but a significant, negative correlation of -.27 in the Dutch group ($p < .05$). Moreover, the correlations in neither group pointed to the presence of a single factor (this issue is taken up in the next section).

Table 7.1 Means (and Standard Deviations) of Metamemory Subtests per Age, for Libyan and Dutch Children

	Libyan		Dutch	
Metamemory Subtest	Grade 3	Grade 5	Grade 3	Grade 5
Memory estimation	15.79 (5.14)	18.69 (5.02)	17.71 (3.54)	21.33 (3.14)
Paired Associates	4.70 (1.47)	5.63 (1.31)	5.92 (1.23)	6.41 (1.09)
Organized List	2.40 (1.41)	3.00 (1.13)	1.87 (1.58)	3.04 (1.20)
Strategy Generation	5.08 (1.72)	5.80 (1.79)	3.66 (1.74)	2.56 (1.66)

Table 7.2 Metamemory Subtests Intercorrelations (Dutch Group above Diagonal, Libyan Group below Diagonal)

	1	2	3	4
1. Memory Estimation		.09	-.29**	.34**
2. Strategy Generation	-.13		-.21	-.57***
3. Organized List	.18	.08		-.27*
4. Paired Associates	.28*	.13	.26*	

*$p < .05$. **$p < .01$. ***$p < .001$.

Finally, correlations between subtest scores and school achievement scores were examined. Almost all correlations had a positive sign, but not many were significant (see Table 7.3). In the Libyan group no correlation reached significance. In the Dutch group significant correlations were found between Mathematics and Memory Estimation (r = .25), Mathematics and Organized List (r = .24), and Reading and Strategy Generation (r = .33; all ps < .05).

In sum, a first screening of the construct validity of the test revealed a mixed pattern. Scores on most subtests increased, as expected. However, that the subtest measures a single metamemorial skill is unlikely. Furthermore, it is not very likely that the subtests behave in a similar way in the two countries. The latter aspect is taken up in the next section, as it challenges the validity of the comparison of scores across countries.

Table 7.3 Correlations between Subtests of the Battery and School Achievement Scores

Subtest	Mathematics	Reading	Grade Point Average
Lybian data			
Memory Estimation	.03	.04	.03
Paired Associates	.14	.09	.09
Strategy Generation	.18	.20	.15
Organized List	.17	.18	.15
Dutch data			
Memory Estimation	.25**	.02	.18
Paired Associates	.14	-.09	.05
Strategy Generation	-.02	.33**	.18
Organized List	.24*	.02	.15

*$p < .05$. **$p < .01$. ***$p < .001$.

7.3.2 Equivalence of the Metamemory Battery

Prior to the hypothesis tests a check was carried out on the equivalence of the Metamemory Battery. The question was addressed to what extent the scales measure the same psychological constructs in each cultural group (Van de Vijver & Leung, 1997). A factor analysis on the four scale scores (not further reported here) yielded a highly incomparable solution in the two cultural groups. Therefore, an analysis of the separate scales was carried out first.

A factor analysis of the three memory estimation scores (ESTa, ESTb, and ESTc) also revealed highly dissimilar solutions. The problem may be due to the use of difference scores in the computation of the three indices. Therefore, it was decided to carry out a factor analysis on the nine separate items (pretest and posttest measures as well as actual performance for three different list lengths). In both countries a unifactorial solution was found with a fairly uniform distribution of the loadings (range: .50 - .72 in Libya and .47 to .78 in the Netherlands). Pupils who thought that they would obtain high scores obtained on average high scores. Tucker's phi, a measure for the factorial similarity in the two countries showed a value of .99, which clearly points to factorial similarity.

The Paired Associates Subtest was supposed to yield a unifactorial structure in both countries; a scree test confirmed this in the Libyan data (explaining 24.0%), while a scree test of the Dutch eigenvalues favored two factors. Tucker's phi of the one-factor solution was .71, which points to important dissimilarities. Three items in the Dutch data showed low loadings. Elimination of these items did not raise the value of phi to an acceptable level. A two-factorial solution showed Tucker's phi values of .46 and .22, respectively. It was concluded that the Paired Associates Subtest did not yield a measure that was comparable across the two groups. The poor equivalence may be due to ceiling effects; all items in both groups were answered correctly by at least 80% of the participants and some by more than 95%.

The Organized List subtest yielded a one-factorial solution, explaining 50.4% of the variance in Libya and 62.7% in the Netherlands. The loadings were homogenous in both countries. Tucker's phi was .99, which pointed to the cross-cultural agreement of the factor.

Finally, a scree test of the Preparation Object subtest did not suggest the extraction of a particular number of factors. Moreover, there was no solution in which the factors were easy to interpret. For example, whereas a one-factorial yielded positive loadings for all categories in the Libyan group, the factor was bipolar in the Dutch group, with most categories having a positive loading, but the third category (external aid, item manipulation) having a strong, negative loading.

Not surprisingly, Tucker's phi was low (.44). Solutions with more items did not show higher phi values. The elimination of one or two items did not raise Tucker's phi to acceptable values.

In sum, the question of whether the Metamemory Test measures the same in Libya and the Netherlands could not be answered affirmatively for all subtests. Only two of the four subtests, Memory Estimation and Organized List, showed a good agreement. Only these two subtests are considered in the remainder.

7.3.3 *Cross-Cultural Comparisons*

A MANOVA analysis with grade, culture, and gender as independent variables (see Table 7.4) indicated a highly significant F value for the main effect of grade (Wilks' lambda = .82, $F(2, 153) = 16.76, p < .001$). Both univariate tests showed that the increases in means depicted in Table 7.1 were highly significant (Memory Estimate: $F(1, 154) = 22.82, p < .001$; Organized List: $F(1, 154) = 22.82, p < .001$). Children in higher grades are better in estimating their memory performance than are children in lower grades. The main effect of culture was also significant (Wilks' lambda = .91, $F(2, 153) = 7.37, p < .001$). Univariate tests showed that the difference was significant for the Memory Estimate subtest ($F(1, 154) = 11.46, p < .01$), with the Dutch children obtaining the higher scores. The country differences were nonsignificant for the Organized List subtest ($F(1, 154) = 1.26$, *ns*). Gender did not show a significant effect (Wilks' lambda = .99, $F(2, 153) = .77$, *ns*). No significant interaction effects were found. An inspection of the proportions of variance accounted for by the systematic effects of Table 7.4 shows that grade differences were by far the largest, followed by culture differences. All other sources of variation showed negligible contributions to the systematic score variation.

Table 7.4 Multivariate Analysis of Variance of Metamemory Subtests (Estimated Effect Size, η^2, in Last Column)

Source of Variation	(a) Multivariate tests Wilks' lambda	*df*	*F*	*p*	η^2
Grade	.82	2, 153	16.76	.00	.18
Gender	.99	2, 153	0.77	.47	.01
Culture	.91	2, 153	7.37	.00	.09
Grade x Gender	.99	2, 153	0.73	.49	.01
Grade x Culture	.99	2, 153	0.93	.40	.01
Gender x Culture	.99	2, 153	0.01	.99	.01
Grade x Gender x Culture	.99	2, 153	0.39	.68	.01
	(b) Univariate tests Variable	*df*	*F*	*p*	η^2
Grade	Mem Estimate	1, 154	22.82	.00	.13
	Organized List	1, 154	17.60	.00	.10
Culture	Mem Estimate	1, 154	11.46	.01	.07
	Organized List	1, 154	1.26	.24	.01
Gender	Mem Estimate	1, 154	0.66	.42	.00
	Organized List	1, 154	1.17	.27	.01
Grade x Culture	Mem Estimate	1, 154	0.28	.59	.00
	Organized List	1, 154	1.80	.18	.01
Grad x Gender	Mem Estimate	1, 154	0.57	.45	.00
	Organized List	1, 154	0.59	.44	.00
Grade x Gender x Culture	Mem Estimate	1, 154	0.65	.42	.00
	Organized List	1, 154	0.29	.59	.00

Table 7.5 Correlations between the Estimated (Pre and Post) and Actual Memory Score for List Lengths of 5, 10, and 20 Items

List length	Culture	Grade	Estimated prestest	Estimated posttest
5 items	Libyan	3	.27	.38*
		5	.30	.30
	Dutch	3	.23	.34*
		5	.41**	.62***
10 items	Lybian	3	.05	.25
		5	.31	.11
	Dutch	3	.04	.66***
		5	-.09	.65***
20 items	Libyan	3	-.02	.09
		5	.19	.44***
	Dutch	3	-.15	.16
		5	-.05	.80***

*$p < .05$. **$p < .01$. ***$p < .001$.

In sum, the overall pattern of findings is simple. Between third and fifth grade, the metamemorial skills of both Libyan and Dutch children increase. We found some cross-cultural differences in level of metamemorial skills, but the differences were found for one test only. The high scores on some subtests among the third graders strongly suggest that at least some aspects of metamemory develop well before the age of nine years.

The Memory Estimation subtest allows for more detailed analysis of metamemorial skills than presented before. Table 7.5 presents the correlations between the actual memory test performance and the estimated pretest and posttest performance. The correlations of the estimated posttest scores are always positive and significant in most cases, whereas pretest estimates are often lower and nonsignificant. A good example is the estimate of the performance on a 20-item list by Dutch fifth graders. Knowledge of performance increased the correlation from -.05 (*ns*) to .80 ($p < .001$). These findings indicate that the children used their actual performance to adjust their estimates. The tendency is particularly salient among the fifth graders. Compared to the skills to estimate the difficulties of learning organized versus unorganized material which seem to develop prior to third grade, the ability to use feedback to adjust memory performance expectations seems to develop later.

Another characteristic of the memory estimates is presented in Table 7.6. Absolute differences between estimated and actual performance per country, grade, and list length are given there. The table corroborates earlier findings: The differences tend to be smaller for fifth graders than for third graders; similarly, posttest estimates are more accurate than pretest estimates. In addition, the differences tend to increase somewhat with list length, but this increase is small. This is remarkable if it is realized that memory performance hardly goes up with list length. Third graders already realize the limits to what can be stored in memory in two minutes.

Table 7.6 Means of the Absolute Difference between the Estimated (Pretest and Posttest) and Actual Performance

		Libyan		Dutch	
Estimate	List length	Grade 3	Grade 5	Grade 3	Grade 5
Pretest	10	2.08	1.75	2.02	1.49
Posttest		1.85	1.78	1.56	1.05
Pretest	15	3.08	2.85	3.02	3.32
Posttest		2.80	3.20	1.83	1.54
Pretest	20	3.83	4.18	4.34	3.59
Posttest		3.55	2.95	3.66	1.34

7.4 Discussion

The study was conducted to explore cross-cultural differences in metamemory performance on a metamemory battery for children, and to investigate the relationship between the children's performance on these tasks and scholastic achievement scores of the two cultural groups.

In a preliminary analysis it was found that not all subtests of the Metamemory Test measured identical constructs in both countries. For the Paired Associates subtest the lack of equivalence was probably due to ceiling effects. Third graders in both countries already know that word associations can help their recall. For Strategy Generation, the reason behind the lack of cross-cultural equivalence was less obvious. The unstructured nature of the question asked to the child may be one of the reasons. The child does not know how many responses are expected. Moreover, there may be differences between countries in the kind of action that is deemed appropriate by the child. For example, whether it is appropriate for a child to ask a parent to help the child to remember may well differ across cultures. This content ambiguity and context sensitivity render the question less adequate for cross-cultural comparisons.

With respect to the first goal, consistent with theoretical predictions and with previous studies using individual administered tasks (Kreutzer et al., 1975; Schneider, 1985), differences between age groups were found; fifth grade children scored higher than third grade children on the equivalent subtests of the battery. Large significant differences between third and fifth grade school children emerged for memory estimation. As described, the memory estimation subtest is tapping children's prediction of memory capacity on different list length. The test was designed to answer the question of whether predicting performance on memory tasks improve in accuracy as a result of experience with such tasks. There was a developmental improvement here. Children made a prediction before attempting a list-recall task. Then, after completing a list recall task they were asked to make another prediction. Comparing the prediction values with actual recall yields the metamemory indicator that is usually interpreted as a byproduct of memory monitoring. It seems that young children were less able to monitor well their memory proficiency in the past and made somewhat less realistic predictions. As was expected, older children are more realistic and accurate in predicting their memory capacity by indicating actual recall in the tasks introduced in the subtest.

An age significant difference in the Organized List subtest points to older children's understanding of the usefulness of organization and grouping to aid memory in subsequent recall. Older children's performance on this subtest indicates the further development of semantic strategies and reflects the fact that there is increasing knowledge of organization strategy with increasing age. The results are consistent with previous findings (Sodian et al., 1986) indicating that younger children are less strategic in clustering and grouping than older children. The older children better appreciated the value of taxonomic sorting strategy. Third grade school children realized less that the organized lists would be easier to remember compared to unrelated words.

With regard to cultural differences in performance on metamemory subtests, there were differences in memory estimation; the Dutch children were more accurate than Libyan subjects in estimating their memory capacity. The memory performance of the Dutch children was also higher. In a series of analyses of variance with culture and the number of items correctly recalled as independent variables and the estimated scores as dependent variables (not further documented here), it was found that the main effect of culture was not significant and that there was no interaction. Dutch and Libyan children with a similar memory performance had on average identical estimated pretest and posttest scores. This finding does not yet clarify the origin of the cross-cultural differences (where do these differences come from?), but makes it likely that the Libyan and Dutch children have a common developmental trajectory.

Second, the often nonsignificant correlations between children's scores on the metamemory subtests and school achievement were not entirely consistent with previous findings that reported a positive relationship between indicators of metamemory skills (i.e., strategy use and strategy generation) and school achievement scores (Borkowski et al., 1983; Kurtz et al. 1988; Kurtz et al., 1982; Schneider, 1985). However, the contradiction with findings in the literature should not be overrated, as most correlations of the present study were positive. Larger sample sizes would probably have produced a larger number of significant relationships.

Thus the present study provided some converging evidence for the validity and, therefore, the utility of the battery for children, although only the Memory Estimation and Organized List subtests appeared to provide a cross-culturally equivalent indicator of metamemory skills. Future research is needed to develop and validate metamemory scales that can be used in a cross-cultural context.

7.5 Summary

Eighty Libyan children (40 third graders, 40 fifth graders) and eighty-two Dutch subjects (41 third graders, 41 fifth graders) were tested, half were boys and half were girls. Subjects received a metamemory battery of four subtests, memory estimation, organized list, paired associate, and preparation object. These subtests cover a broad range of metamemory knowledge. Correlations between subtest scores and school achievement

scores were positive but weak. Only two subtests, the Memory Estimation and Organized List subtests, showed structural equivalence. There were age differences on both subtest, older children scored higher than young subjects. Cross-cultural differences were found for the Memory Estimate subtest, with the Dutch children obtaining higher scores.

Chapter 8

Conclusions

Memory processes of storage and retrieval of information have been influential in determining the direction of memory research. Models have been developed to delineate memory mechanisms and to explain how various components interact and shape memory behavior. It has been argued that structural features of memory are invariant across a wide range of experimental conditions and across cultural populations. Processes of memory control or mnemonic strategies have been proposed to be culturally variable aspects of memory. From this distinction originates in part the cross-cultural comparative research in memory.

An important distinction is between short-term memory and long-term memory. The latter form of memory is involved in forgetting over longer periods. Short-term memory, which has attracted most attention, acts as a working memory; it plays a major role in cognitive activities, such as learning, comprehending, and reasoning. Various conceptions of working memory have been proposed. One of these is the articulatory or phonological loop, which postulates a fixed time interval during which information remains accessible (Baddeley et al., 1975). This model explains variations in storage capacity for a large number of factors that influence memory span, including chunking (storing information in subjectively meaningful units), word length, acoustic similarity, and speech rate. These factors have been examined developmentally and across languages, with important differences being found in respect of both. A profound difference in memory span and time required to pronounce digits was found between languages. The relations between word length in a language and both reading speed and memory span seem to be approximately linear for a number of languages studied (e.g., Chincotta & Hoosain, 1995; da Costa Pinto, 1991; Naveh-Benjamin & Ayres, 1986; Stigler et al., 1986; Zhang & Simon, 1985;).

In the first of our three empirical studies differences that were found between older and younger primary school children and between Libyan and Dutch children in memory span could be partly explained in terms of differences in reading speed for the words concerned. This was brought out clearly by the manipulation of a feature in the Arabic language, namely the existence of a short and a long form for numerals. This does not rule out that there are also differences in reading speed for words and digits due to the amount of time spent practicing the pronunciation of words. Such practice is likely to underlie the developmental increases in reading speed that we observed. It has also been suggested in the literature that it might be premature to conclude that cross-linguistic differences are entirely due to differences in pronunciation time. Although the phonological loop model fits our data well in some respects, it has to be noted that this model could not explain all the variance. In particular, differences in memory span between boys and girls in the Libyan sample could not be accounted for in terms of reading speed.

Memory performance can be influenced by various strategies of acquisition and retrieval. The most important of these are rehearsal and organization of the information to be remembered. Age-related differences in performance have been widely attributed to differences in the use of such strategies. Differences in strategies have also been clearly implicated in cross-cultural research in memory tasks reported in the literature. Inducing various acquisition strategies has been suggested as one important way of producing increased recall. In memory span tasks, high performance requires the use of verbal rehearsal, and fast rehearsers can rehearse more words in the limited time available to refresh traces in the phonological store, so that rehearsal is perhaps the simplest strategy that can be used in a deliberate memory task. Rehearsal is generally viewed as an iterative process by which information in short-term memory is continually refreshed. The use of rehearsal strategy was investigated in the second study by training Libyan and Dutch children of lower to middle grades of primary school to rehearse words in clusters. The results clearly indicated that memory span can be enhanced with training, and that old children benefit more from training.

The third of our empirical studies was an exploratory analysis of metamemory among ten- to twelve-year-old Libyan and Dutch children and its relationship to school achievement. Metamemory, i.e., the knowledge that a person has about the functioning of his or her memory, has emerged as a multifaceted concept that appears to be rather task specific. Metamemory skills among young children are very limited and individual development continues at least until adolescence. There are few cross-cultural studies of metamemory, and these have included only Western populations.

Examinations of metamemory in children have generally used individual procedures. There are various indications that many of these have low levels of consistency. For the present study an adaptation of a test battery developed by Belmont and Borkowski (1988) was used, consisting of four subtests. Preliminary analyses of the structural equivalence of the battery revealed that two subtests had to be discarded from the cross-cultural comparisons. Data on the remaining subtests (dealing with memory span estimates and the recognition that recall of organized material is easier than the recall of unorganized material) collected from Libyan and Dutch primary school children showed an increase with age. The results showed that older children have a more realistic assessment of memory capacity and a better understanding of the usefulness of organization. Dutch children obtained higher scores than the Libyan children on the Memory Estimate subtest. The correlations between the two subtests were positive and significant (around .30); correlations between the measures of metamemory and school performance were low but often positive. These results can be interpreted as pointing to the multifaceted character of relationships with school achievement.

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Summary

Primacy and recency are among of the most interesting phenomena in memory. When subjects are presented with a list of unrelated words in a free recall task, there is a tendency for the first few items as well as the last few items to be well recalled, while the items in the middle of the list are often forgotten. The recall of recent items is unaffected by variables that might affect the recall of other items on the list, such as list length, presentation rate and word familiarity. This has been taken as an indication against a unitary conception of memory and has led to a distinction between short-term and long-term memory stores. The most recently presented items are held in a temporary short-term store, while earlier items are recalled from long-term memory. In a delayed recall task, long-term memory is presumably involved, while short-term memory is assumed to be involved in immediate recall. There are age-related differences in delayed recall, while age differences disappear in immediate recall.

Encoding is the operations that an individual performs on experienced events, including procedures that are deployed during study of materials in preparation for subsequent recall. These procedures are termed mnemonic strategies. Rehearsal has been studied most intensely. Distinctions have been made between two types of rehearsal, maintenance rehearsal and elaborative rehearsal. The former involves rote repetition of to-be-remembered material without thought about the meaning. Subjects using this type of rehearsal are expected to perform poorly on recall tasks. The second type, elaborative rehearsal, is more effective in providing retention. Rehearsal strategies are not found among 5-year-olds children. Older children tend to rehearse spontaneously, and rehearsal set size increases with age. Young children use cumulative rehearsal only when they are instructed to do so. By the age of 10 years children start to use cumulative rehearsal spontaneously. Age differences in rehearsal are rarely eliminated, even with extensive training.

Organization is another memory strategy deployed by children. When children learn lists of items that are drawn from salient categories, their recall often is organized categorically. Such item organization during recall reflects associative processes during retrieval. Developmental studies on semantic grouping during free recall reported greater output clustering with increasing age. Training can play a major role in the improvement of organizational strategies.

Research on forgetting has established two theoretical frameworks to explain forgetting. One theory is based on the assumption of information decay in short-term memory as a result of automatic fading of a memory trace. The other theory involves the principle of interference of information in long-term memory as a result of disruption of a memory trace by other traces. Age differences in forgetting were found in a number of studies. Although forgetting rate is invariant across ages, older children recall better, utilize cues more effectively and adopt strategies to minimize interference more than younger children do.

Metamemory has been a topic for empirical research mainly in western countries.

Both the conceptual and the empirical development of the metamemory construct have been limited by a lack of reliable and validated assessment techniques and by a failure to replicate basic findings across studies. Research in metamemory development was conducted in support of Flavell's (1971) theory that metacognitive knowledge affects children's memory behavior. Metamemory knowledge includes persons, tasks, strategies and the interactions of these variables. The person variable refers to whether children understand qualities of their own memories and those of other people. The task variable refers to knowledge about what makes one task more difficult than another. The strategy knowledge includes various encoding and retrieval strategies.

Earlier research in metamemory development (e.g., Kreutzer et al., 1975) indicated that children's knowledge about memory starts quite early and is relatively complete by grade three. More recent research has established that knowledge about person, task, strategy and the interaction of these variables continue to develop into early adulthood.

The most important question in metamemory research has been the connection between metamemory knowledge and memory performance. Previous research failed to produce a significant relationship between metamemory and memory behavior. The use of metamemory indicators that were directly relevant to memory tasks revealed a significant relationship between metamemory knowledge and memory performance in school children that increased with age. Recent research on metamemory has included the role of home environment and teaching methods in school in shaping and developing strategic behavior of children. Interactive relationships were found among such variables.

Cross-cultural research in memory development previously focused on children's performance on memory tasks as a result of schooling and social environment. Based on memory models, a set of features was postulated that included both structure and control processes. Structural features are assumed to be present in all subjects regardless of age or experiential background. Control processes such as rehearsal and clustering were found to be influenced by schooling and urban living. Earlier cross-cultural studies (e.g., Cole et al., 1971; Wagner, 1978) provided support for such a theoretical model. The results of short-term recall tasks showed that verbal rehearsal appeared to be used only by older school subjects and to some extent by unschooled children. Also, clustering as a memory strategy was found to vary with age, task, and social environment. In contrast, structural aspects of memory such as forgetting rate, short-term store and recency were found to be invariant.

Recent cross-cultural research in metamemory development has examined home environment and motivational attributions as related to children's memory performance. The results indicated that individual differences in metamemory might result from educational experience in school and self-generated acquisition of memory skills.

There are three cross-cultural studies included in this report. The first study examined the development of memory span in Libyan and Dutch primary school children. The subjects were tested on memory span and reading speed for digits and long and short words. In answering the question of why memory span increases with age, Baddeley and Hitch's (1974) articulatory loop model was put forward. The results showed span increases with age and cross-cultural differences in memory span and reading speed. There was support for Baddeley et al's (1975) findings that the immediate memory span for short words is larger than for long words and for their idea that fast rehearsers can rehearse more words in the limited time available to refresh memory trace in the phonological store.

Word length effects could be investigated in the Libyan sample with a feature of the Arabic language, namely the existence of a short and a long version of the numerals from one to ten. The results indicated that the size of span was larger for short digits.

The influence of reading speed on memory performance was assessed using a structural equation model. Four or three (for the Dutch sample) reading speed measures (short and long digits, short and long words) defined a single latent factor, called reading speed. Analogously, a latent factor, called memory span, was defined by memory span measures. A good fit of the model was found. In line with Baddeley's model, reading speed showed a positive impact on memory span. The analyses underscored the feasibility of the phonological store hypothesis; both reading speed and memory span constitute a latent factor and these factors are related to each other. Children who have a higher reading speed tend to show better performance on memory span tasks.

A final analysis addressed the question to what extent the phonological loop model could account for observed differences due to age, gender and country. If the model could explain all these differences, it would imply that age, gender and country differences in memory span are all due to differences in reading speed. In an analysis of covariance it was found that country differences could be completely accounted for and age differences partially. However, gender differences could not be explained at all. In sum, the phonological loop model provided a partial explanation for the observed main effects. In particular the observation that girls had a slightly higher memory span and a lower reading speed than boys is not accounted for by Baddeley's model.

The second study investigated the effect of rehearsal training on memory span of Libyan and Dutch children of six to eight years. Memory researchers concerned with the development of serial recall have suggested that training children to rehearse at a higher speech rate would produce a corresponding increase in serial recall performance (Flavell, Beach, & Chinsky 1966). Subjects in an experimental group were trained to recite lists of words, starting on the list length that they had failed in a pretest. Subjects in a control group were exposed to the training material for the same period of time, but received no instructions on how to rehearse the items. A significant age difference was found, older children's recall was higher than that of younger children. Also, the effect of training was significant. There was a cross-cultural difference, Libyan children performed slightly higher than the Dutch participants, more so in the experimental group than in the control group. The results of the training fell short of the hypothesis that trained younger children would reach the same level as untrained older subjects.

Probably, the younger children would have needed more training to improve fully to the level of the older subjects.

The third study was conducted to explore metamemory development of Libyan and Dutch children in third and fifth grade. A group-administered battery developed by Belmont and Borkowski (1988) was adopted with some modifications. The test consists of four subtests covering a broad range of metamemory aspects. The four subtests are memory estimation, organized list, preparation object, and paired associate subtest. An examination of the cross-cultural suitability of the four subtests revealed that for only two subtests it could be demonstrated that they measured the same in Libya and the Netherlands: Memory Estimate and Organized List. Scholastic achievement scores of the subjects involved in the study were collected from schools. Age differences were found; older subjects scored higher than the younger ones on both subtests. This is consistent with previous findings and with the general assumption of metamemory development. Dutch children performed better than the Libyan subjects on memory estimation. No gender differences were found. Correlations between the metamemory subtests and school achievements were weak, though usually in the expected direction.

It is clear that more theoretical and methodological problems were met in the third study than in the first two. Various reasons can be envisaged for these problems. The formulation of metamemory construct is not yet clearly developed. Compared to the specific hypotheses about short-term memory, metamemory is still underdeveloped. The second problem is related to the first one: the measurement scales still require various refinements. We already have various memory scales that have been used extensively in cross-cultural research, but there are no scales for cross-cultural research of metamory. The present study shows that metamemory can be a fruitful topic for cross-cultural theory and research. It is an interesting area as it involves presumably universal mechanisms, such as the role of rehearsal and semantic categorization in recall, that are used on culture-dependent knowledge.

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Cross-cultural memory research is scarce. The present study set out to investigate memory development in Libyan and Dutch children. Three studies have been carried out. A unique feature of the Arabic language, the presence of both short and long names for the same digits, was used in the first study to examine the relationship between reading speed and memory span. Results indicated that there is a positive effect of word length and reading speed on memory span of the children. The second study showed that rehearsal training does increase memory span in both countries. The final study addressed differences and similarities in metamemory in children of the two countries.

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